The AMSAT® Journal

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AMSAT Live from the Smithsonian Air and Space Museum. Attending the IMAX premier of *Space Station* are (l to r) Perry Klein, W3PK; Ken Nichols, KD3VK; Mark Steiner, K3MS; Will Marchant, KC6ROL; Frank Bauer, KA3HDO; Dave Taylor, W8AAS; and Dick Daniels, W4PUJ. (photo by Art Feller, W4ART)

ARISS at the Smithsonian

Will Marchant, KC6ROL

The IMAX Corporation (*http://www.imax.com/*) has been working closely with NASA to document the space program in a series of impressive films. Their latest movie is about the construction of the International Space Station and it was recently unveiled at the Smithsonian's National Air & Space Museum, Washington, DC.

The ARISS team had worked closely with IMAX to film a school contact both in orbit and on the ground. Due to scheduling constraints, the space and ground segments were different school contacts joined together with cinematic legerdemain. The result is delightful and excel-

[continued on page 4]

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The AMSAT Journal staff is always interested in article submissions. Whenever possible, text should be on IBM compatible diskettes with hardcopy or original photographs or figures. AMSAT-NA reserves the right to select material for *The AMSAT Journal* based on suitability of content and space considerations. The editors of this publications are volunteers giving freely of their talents, time, and efforts to produce *The AMSAT Journal*.

Apogee View

Satellite Costs and Funding

As AMSAT members, all of you are very much involved in the design, building and launching of our satellites. You may not realize how much you are involved because I am not constantly knocking at your door, soliciting your individual views or asking you for your technical advice on every subject. However through meeting many members at Dayton Hamvention and other Amateur Radio gatherings, together with my daily reading of the AMSAT-BB and your feedback presented to members of the Board of Directors and other officers, a picture evolves of your satellite needs and thoughts for future birds. This information is discussed by the Board of Directors very regularly, and has resulted in AMSAT-NA developing two very different satellites simultaneously.

You may ask (and I expect you do) how we can afford to do this - particularly as we are always asking for more funding, and pointing out that the satellites cannot go ahead without your financial assistance. Let's look at the relatively simple mathematics of financing a satellite.

From our experience of over 30 years we can estimate the approximate value of a satellite such as *Eagle* relatively accurately even before the design has started. By knowing the on board systems, many of which may have been used before, it is a relatively easy exercise to determine that Eagle would cost something in the order of $600,000 to design, build, assemble or integrate and test. On top of this cost comes the launch cost, which is the big variable. Several of our previous launches have been carried out on prototype launch vehicles, where the launch operators are quite pleased to put an actual satellite into orbit, because the commercial satellites will generally not take the risk of riding on a prototype launch vehicle. These launches are not happening as frequently as they used to, but we are always looking out for a ride at a suitable price. Some of the launches have a base price for up to a certain weight / size, this base price looks after all the paperwork involved in preparing for a launch and the launch cost, other launch agencies have a schedule of charges based on weight or size.

By reducing the size of *Eagle* we may possibly reduce the launch charges but we will increase the cost of the solar cells as more expensive high efficiency solar cells are needed to produce the same power. However we can benefit from this situation as, by having a smaller satellite, we can make the design suitable to fit a variety of different launch vehicles, leaving us with a choice of which launch agency to use. Cutting through the launch dilemma we can estimate that the minimum cost for the launch of Eagle will probably be around a million dollars (Yes $1,000,000) and the maximum around two million dependent of how reliable the launch will be.

So *Eagle* will cost around $1.6 to $2.0 million. How can we finance this? Our main source of financing is from the AMSAT members around the world, but specifically the members of AMSAT-NA.

Let's assume that we will raise the money over three years then this amounts to $666,666 per year or $133 per member each year to the project fund, over and above the membership fee.

For members who live in the USA receipt is issued which may be used to offset personal income tax, for Canadian members we are actively pursuing this option and I hope to be able to report on this later on during the summer. While $133 is not a big deal for most of AMSAT's members, particularly when a tax receipt is available, is a new satellite worth it to you?

OSCAR-Echo is a new Low Earth Orbit satellite, and a description of it appears as an article in this issue of *The AMSAT Journal*. Basic financing for this satellite has come from our reserve funds, which were recently boosted by our mentoring of the University of Toronto MOST satellite. Our volunteers put a large amount of time and effort into this satellite, and the resultant funding to our reserves has enabled AMSAT to work closely with the SpaceQuest organization in the development of *OSCAR-E*. I recommend that you read the article on this satellite.

It is with sincere regret that I have accepted the resignation of Russ Tillman as Editor of *The AMSAT Journal*. As many of you may know Russ has been the Editor of this publication for seven years, far longer than any of the previous Journal editors. Russ has been at the forefront of changing technology for producing the Journal, and developing the CD archives. Through this page of the Journal, I thank Russ for the many dedicated hours of work which he and his editorial staff put into each copy of this publication. According to my records Russ started as editor for the May/June issue of 1995, which makes this issue his forty-fourth, including the special edition for the launch of AO-40. A great effort - Thank you again Russ. 73, Robin Haighton, VE3FRH ■

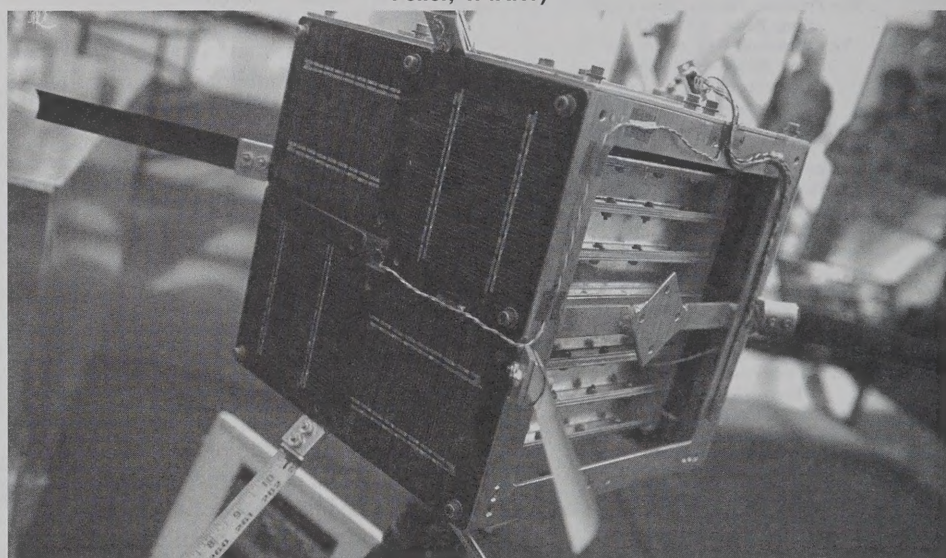
lent publicity for Amateur Radio!

"It was pretty awesome to see Bill Shepherd, KD5GSL talk to the Texas students with our ARISS equipment in 3D," ARISS Manager Frank Bauer, KA3HDO said afterward. "This is a *must see* movie." *Space Station* is the first 3D IMAX space movie. The film was made possible by NASA and is presented by Lockheed Martin and narrated by Academy Award nominee Tom Cruise.

Seabrook Intermediate School in Texas provided the earthbound setting for ARISS' role in the IMAX production. Footage with Shepherd answering a question during a school contact was shot in January 2001 during Shepherd's tour of duty as Expedition 1 commander. The question segment and the answer segment then were matched up during editing for the final production.

Because of the close ties between ARISS, IMAX, and the Smithsonian, the ARISS organization was invited to host a booth at the press and VIP pre-release screenings of the new film. Frank Bauer, KA3HDO and Ken KD3VK undertook the effort of organizing the booth and volunteers to answer questions. With a lot of help from the Washington, DC Amateur Radio community they put on an excellent display for the press on one day and for VIPs on the second. While Tom Cruise, who narrates the film, did not stop by the booth (he was whisked into a showing of the film and departed immediately thereafter) we had lots of visits from astronauts, cosmonauts, corporate, and government officials. Everyone was very complementary about the role of the Amateur Radio community in the space program. Congratulations to AMSAT for their support of space flight education! ■

Where's the popcorn! From left to right, Martha Saragovitz, Bob Bruninga, WB4APR, and Perry Klein, W3PK await the IMAX 3D presentation of *Space Station.* (photo by Art Feller, W4ART)



A prototype of PCsat was displayed at the ARISS exhibit. (photo by Art Feller, W4ART)

ARISS Manager Frank Bauer, KA3HDO; Captain Bill Shephard, KD5GSL and Commander of ISS Expedition 1; and Johnson Space Center ARISS Coordinator Carolyn Conley, KD5JSO pose in front of the ARISS exhibit. (photo by Dick Daniels, W4PUJ)

Figure 1. Meeting at SpaceQuest, 08 February 2002. This photograph was taken during a joint meeting of the project team and the AMSAT-NA executive committee with SpaceQuest. Shown, clockwise from the left, are Linda Jacobsen (SpaceQuest); Art Feller, W4ART (AMSAT-NA Treasurer); Rick Hambly. W2GPS and Dick Daniels, W4PUJ (AMSAT OSCAR-E project team); Dino Lorenzini, KC4YMG (SpaceQuest); Robin Haighton, VE3FRH (AMSAT-NA President); and Keith Baker, KB1SF (AMSAT-NA Executive Vice President). In attendance but not shown is Mark Kanawati, N4TPY (SpaceQuest).

AMSAT OSCAR-E
A New LEO Satellite from AMSAT-NA

Rick Hambly, W2GPS (w2gps@amsat.org)

AMSAT-NA has embarked on the construction of a new Low Earth Orbit (LEO) satellite that will be called AMSAT OSCAR-E, or *Echo* until it achieves orbit and receives the next sequential OSCAR number. Keith Baker, KB1SF was referring to this satellite when he introduced a new "MICROSAT-class project" in the Apogee View column of the last issue of *The AMSAT Journal*.

Notice that with this satellite AMSAT is returning to the practice of designating LEO satellites by sequential characters. This was last done for AMSAT OSCAR-D, which became AMSAT OSCAR-8 after launch and commissioning. AMSAT didn't use letters for the first four Microsats and the Phase 3 series started again with "A".

It has been 12 years since AMSAT-NA built and launched the original Microsats in 1990, and 8 years since AO-27 was launched in 1993. AMSAT OSCAR-E will put AMSAT-NA back in the satellite business while providing an improved companion for AO-27, which has been very popular with hams for the past 8 years, but is getting old. Space and power are available for one or more optional payloads that will be provided by AMSAT volunteers.

The AMSAT OSCAR-E project team is led by Dick Daniels, W4PUJ and includes Tom Clark, W3IWI and Rick Hambly, W2GPS. Oversight of the project team is provided by the AMSAT-NA executive committee and the Board of Directors. The core of AMSAT OSCAR-E will be built by SpaceQuest, Ltd. a company that is owned and staffed largely by AMSAT-NA members including Mark Kanawati, N4TPY and Dino Lorenzini, KC4YMG.

The remainder of this article will be divided between an overview of the core satellite systems and descriptions of candidate optional payloads. (The information in this article borrows heavily from *Microsat Mission Study Report* by Mark Kanawati, N4TPY, commissioned by AMSAT-NA and submitted by SpaceQuest, Ltd. to AMSAT-NA on 09 January 2002.)

AMSAT OSCAR-E: Core Subsystems

In the decade since AMSAT-NA built the Microsats, SpaceQuest has made many improvements to the Microsat concept.

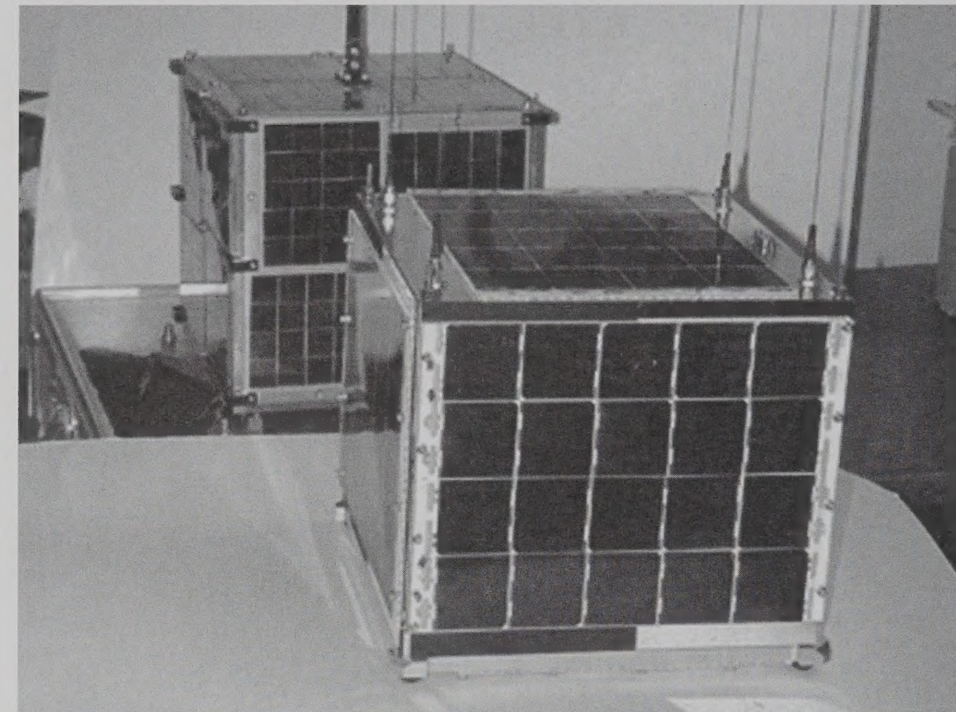


Figure 2. A mockup of AMSAT OSCAR-E in front of an original AMSAT Microsat.

AMSAT OSCAR-E's core subsystems closely resemble those of the original Microsats but show the benefit of years of development and technology advancements.

The subsystems that make up the core elements of AMSAT OSCAR-E are:

- The physical structure
- Attitude control
- Central processor hardware
- Spacecraft flight software
- Power generation and distribution
- Command and control – ground station and satellite
- A basic set of receivers, transmitters and antennas
- Space for optional payloads

The satellite with just this set of subsystems will have an impressive array of functions including FM voice operation (EasySat), 9600 bps data channel(s), and a multi-band receive capability.

AMSAT OSCAR-E is a Microsat class spacecraft weighing approximately 10 kg. The spacecraft consists of five solid aluminum trays, each with four walls and a bottom stacked to form approximately a 10-inch cube structure. A top cover is provided for the top tray. Six solar panels attach to each of the six sides for power generation. Additionally, several antennas protrude from the top and bottom surfaces. Figure 2 is an example of what the AMSAT OSCAR-E structure might look like, although the antennas will be quite different. Note the similarity to AMSAT's original Microsats, as shown by the full size model in the background. These original Microsats were AO-16, DO-17, WO-18, and LO-19. They were followed by the descendents of that legacy, including IO-26, AO-27, MO-30, and SO-41.

Internally the spacecraft consists of a various electronic subsystems including:

- 4 VHF receivers,
- 2 UHF transmitters,
- 6 modems,
- Flight computer,
- RAM disk,
- Batteries,
- Battery charger and voltage regulators,
- Wiring harness,
- RF cabling,
- RF switching and phasing networks,
- 56 channels of telemetry, and
- Magnetic attitude control.

Figure 3 shows a conceptual block diagram of the AMSAT OSCAR-E spacecraft. The items enclosed in dashed lines are not a part of the basic AMSAT OSCAR-E mission, but are under consideration as secondary payloads.

Physical Structure

AMSAT OSCAR-E's overall structure consists of a stack of five machined aluminum modules. Each module measures approximately 9.5 inches x 9.5 inches. The height of each module is adjustable up to a total of 9.5 inches. The nominal useful internal area is approximately 8 inches x 7.5 inches. Each module houses a different spacecraft subsystem.

Modules are interconnected by RF cables and a wiring harness carrying power, intermodule data, telemetry, and control signals. Four machined rods running the height of the spacecraft are used to bolt the assembly together. Figure 4 shows a photo of a typical Microsat structure.

AMSAT OSCAR-E employs a passive thermal control system and has no on-board propulsion. Almost all of the satellite's surface area is covered by solar cells. Some surface area is required for antenna mounts and launch vehicle interfaces. The remaining surface area is covered with thermal absorbing and reflective tape to balance the spacecraft's thermal behavior.

A separation mechanism needs to be designed to adapt the satellite to a particular launch vehicle. Finalizing the separation mechanism will await selection of a launcher although one version already exists for the Russian Dnepr launcher due to SpaceQuest's previous use of that launch vehicle. Dnepr is a de-militarized Russian ICBM.

A standard commercial shipping container will be used to transport the AMSAT OSCAR-E to the launch site.

Attitude Control

The basic AMSAT OSCAR-E passive attitude control system consists of two permanent magnets that align the satellite's vertical axis with the Earth's magnetic field, four hysteresis damping rods that control the satellite spin rate, and reflective/absorptive tape that cause the satellite to rotate about its Z-axis as a result of solar photon pressure. This simple, no-power technique has been demonstrated to work well on several previous Microsat missions. The solar-induced spin averages out the thermal load on

the satellite, while the permanent magnets allows one end of the satellite to point generally towards Earth.

The many advantages of this simple passive attitude control system are offset by one significant limitation. The permanent magnets cause the satellite to make two rotations per orbit resulting in one face favoring the Northern Hemisphere and the opposite face favoring the Southern Hemisphere. The Earth-pointing direction is on the order of ±20 degrees in the temperate zones, varying with orbital inclination.

Central Processor Hardware

AMSAT OSCAR-E includes an Integrated Flight Computer including the central processor unit (CPU), random access memory (RAM), RAMDISK, and modems. All of these functions are incorporated on a single, multi-layer, both-sides-populated PC board.

The CPU is a flight-proven, low-power NEC V53A processor. This processor first flew in 1993 on AO-27, and has flown on a number of LEO missions since. It is based on an x86 core and runs the Spacecraft Operating System (SCOS), also flight proven on numerous spacecraft. See Figure 5.

The processor is clocked at 29.412 MHz, running the bus at 14.7456 MHz. This yields three times greater processing throughput and three times faster interrupt response than previous missions using this processor.

The boot ROM uses a standard CMOS EPROM running a variant of the Microsat Boot Loader (MBL). The EPROM is divided into two sections, alternately mapped into memory space with each RESET command. Thus, if a partial failure of the EPROM occurs, the satellite operating system can still be booted. This technique has been flown successfully for several years.

The main memory system is error-detecting and correcting (EDAC) using bit-wise triple mode redundancy (TMR). TMR allows the safe use of wide-word memory, in this case 512Kx8 static RAM (SRAM) chips. The overall EDAC memory size is one (1) megabyte. A portion of this memory space is remapped to allow the boot read-only memory (ROM) to occupy the highest memory addresses.

A RAMDisk consisting of 16 megabytes of serial-accessible static memory are provided for bulk storage of data. This memory has no hardware error correction mechanism, so error control must be handled in software. This technique has successfully been used since the Microsats launched in January 1990.

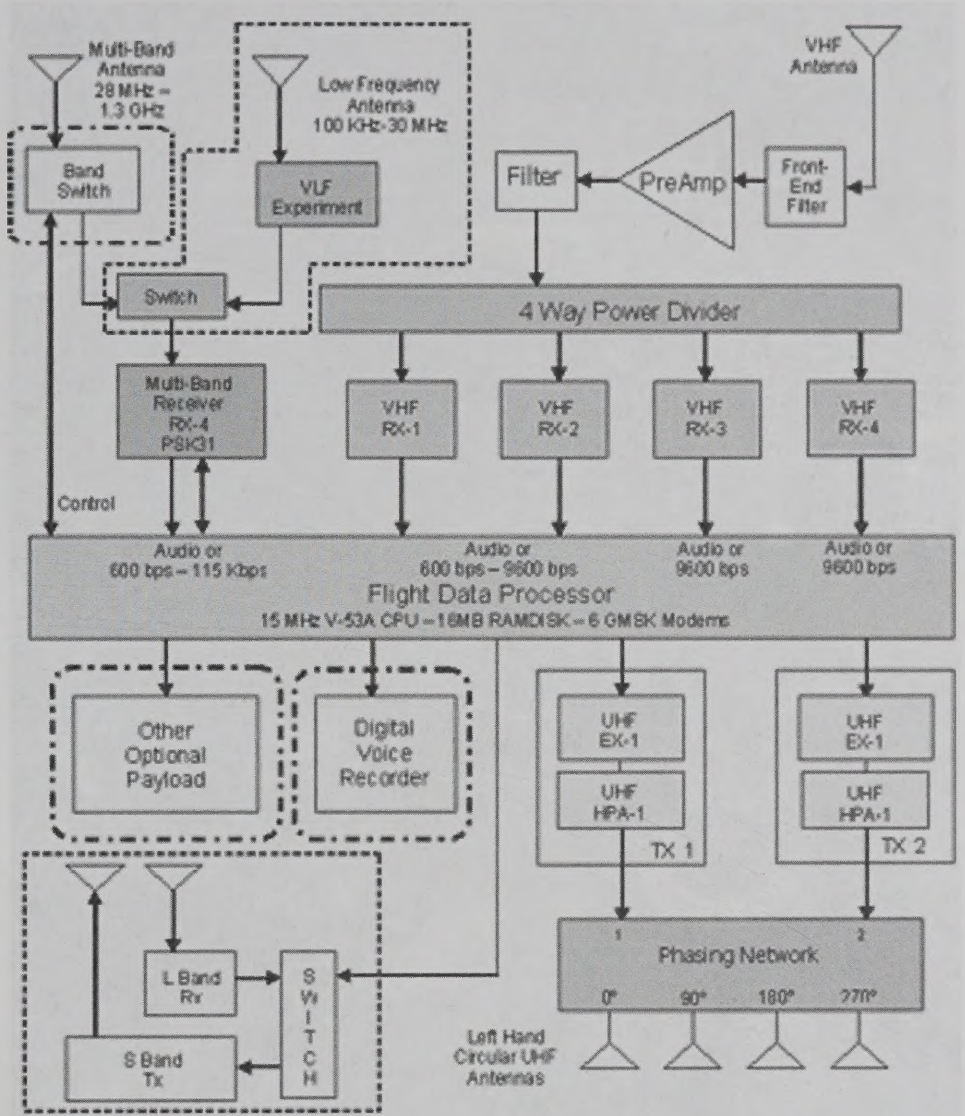


Figure 3. Conceptual Block Diagram of the AMSAT OSCAR-E Spacecraft.

A 16 megabyte NAND-Flash memory is included for rapid re-booting of the operating system and application tasks after RESET. This is modeled after the successful FLASH operating system image reload facility of IHU-2 aboard AO-40.

Six (6) GMSK modems are included. At least one will be fixed-rate for primary command and control of the spacecraft. Each modem is attached to a dedicated multi-protocol serial port based on the NEC 72001 SCC. Two of the modem uplink channels are fitted with firecode detectors to provide ground-commandable RESET regardless of the state of the CPU. The variable-rate modems can go as slow as 600 bit/s and as fast as 115.2 kbit/s. The uplink and downlink data rates are set independently. Two (2) of the modems are DMA-capable, the other four (4) are interrupt-driven only. Care must be exercised to ensure the CPU is not overloaded with interrupts during mission planning and general spacecraft operation.

Up to eight (8) open collector N-channel FETs provide power switching control (low side switching) and several bits of 3.3V CMOS-level I/O are included. A pair of SPI ports is available for command and control functions to various modules in the satellite.

Approximately 56-channels of telemetry will be gathered on board AMSAT OSCAR-E. Eight-channel telemetry boards with 10-bit analog-to-digital converters are located in four of AMSAT OSCAR-E's trays. A Serial Peripheral Interface (SPI) bus links the telemetry boards to the central processor. Twenty-four telemetry channels are built into the Battery Control Regulator (BCR) board. The telemetry includes:

- All of the solar panel voltages, currents and temperature,
- Battery voltages, currents, temperature

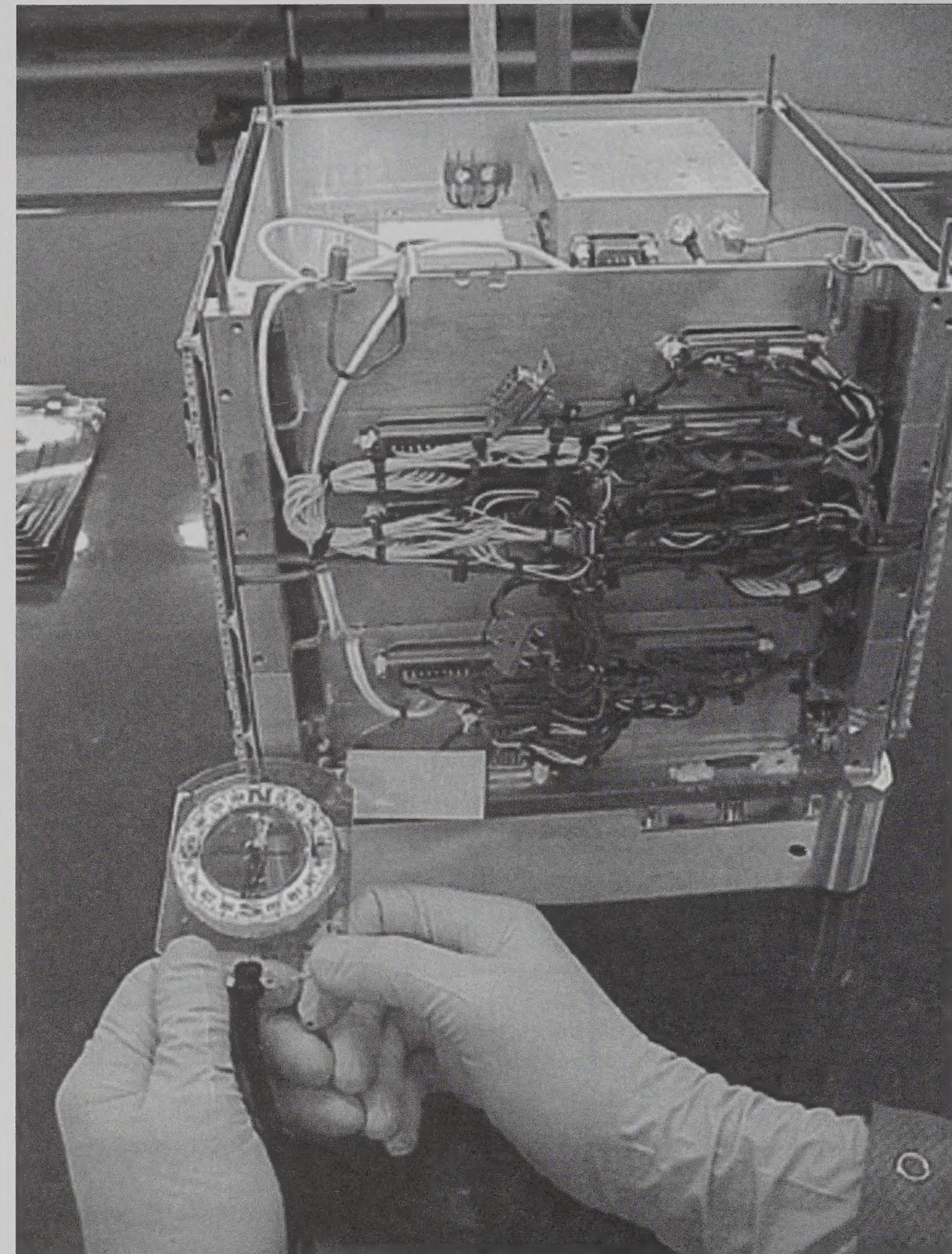


Figure 4. Typical Microsat Structure.

and charge polarity;

- BCR regulated voltages and currents;

- Temperature of the receiver, transmitter, central processor, and switching regula tors;

- Multi-band receiver signal strength indi cator; and

- The high-power amplifier output and reflected power on both transmitters.

A dedicated SPI bus is used to channel the telemetry from the BCR and the individual telemetry boards to the central processor.

Spacecraft Flight Software

The boot loader provides the minimal set of functions required to verify the satellite health and load the operating system. The boot loader runs on the initial power up, and whenever a software or hardware reset occurs. Because it resides in permanent memory and cannot be changed after launch, the boot loader is simple, robust and proven.

The boot loader provides the capability to:

- Send acknowledge beacons

- Upload new software

- Download memory locations

- Peak and Poke memory and I/O

- Load software from FLASH or error-detecting and correcting memory (EDAC), and,

- Execute operating system by command or timer

The Spacecraft Operating System (SCOS) has been used on all of the Amateur Radio Microsat projects to date. The operating system and the housekeeping task are contained in EPROM and are moved into RAM for execution by the boot loader. In addition to detailed telemetry reporting, the housekeeping functions include control of the power system, transmitters and receivers. If needed, it can also support minimal attitude control. As was the case for the boot loader, the operating system and minimal housekeeping task are unchangeable after launch. However, updated versions of these programs can be uploaded and executed after launch. In order to be robust and proven, this version of the housekeeping is kept as small as possible. The list of off-the-self programs that execute as tasks include:

- Memory file manager (M-FILE) from Surrey Satellite Technology Ltd (SSTL),

- PACSAT File Transfer Level 0 (FTL-0) from SSTL,

- Transmitter Scheduling and Power Monitoring from SpaceQuest, and

- Supervisor Task Loader and Monitoring from SpaceQuest.

The Mission Software provides complete control over all aspects of the satellite, including experiments and attitude control. This software can be loaded into FLASH from the ground after launch, which allows for flexible development and deployment of new software. The complete set of software should include:

- Multitasking Spacecraft Operating Sys tem (SCOS) from BekTek

- Advanced Task Supervisor

- TX and RX muxing and control

- Telemetry monitoring, storage and reporting

- RAMDISK management and PACSAT protocol

- Scheduling for regional satellite access

- Magnet torquer and IR attitude control

- Optional experiment control

- Additional experimental tasks, such as the digital recorder

Power Generation and Distribution

The AMSAT OSCAR-E Power Subsystem consists of a Battery Control Regulator (BCR), GaAs solar panels, matched flight cells, voltage regulators and a power activation switch. A block diagram of the power subsystem is shown as Figure 6.

The Battery Control Regulator (BCR) provides a power control system designed by SpaceQuest for small satellites. Its function is to convert solar panel power to system power, and manage battery charge and protection. The BCR takes power from solar panels with necessary restraint so as not to draw too much current and lose panel efficiency. The main converter on the BCR uses this solar panel power to charge the system battery, with similar restraint so as not to overcharge the battery. The battery charge system sets maximum charge voltage according to cell temperature, to maximize charge storage while avoiding overcharge and cell heating. The charge regulator is also prevented from reducing solar panel voltage below a preset voltage, to maximize panel output power. The maximum battery charge voltage set point and the minimum solar panel voltage set point can be adjusted by external computer control. The battery charge regulator is a switching design with a measured efficiency of 89 percent.

The BCR is designed to operate autonomously, with CPU supervision for fine-tuning of default parameters. The BCR will safely manage battery charge during the critical period after separation and before ground operators establish control. On-board software can then fine-tune the solar panel and battery charge limit set points for maximum performance with minimum attention.

Six GaAs Solar Panels, which are mounted on all six sides of AMSAT OSCAR-E, produce a bus voltage of approximately 16 volts. The cells have not been selected yet but the minimum efficiency will be 19 percent and cells with efficiencies up to 28 percent are available. The choice depends on their price and availability at the time the solar panel decision is made.

The battery configuration is six NiCd cells at 4.4 Ah each with a nominal battery voltage of 8 V dc depending on temperature and charge state. These matched batteries have been flown successfully on previous Microsat missions and are well-characterized on orbit.

The BCR provides multiple switched 8-V lines for both transmitters and other high power applications. There are also 3.3-V and 4.6-V switching regulators, capable of over 250 mA output each, with multiple switched and unswitched outputs.

Separation-switch circuitry is included on the BCR to turn all systems off while the satellite is mounted on the rocket. An external connection port is provided with two levels of separation switch override to safely

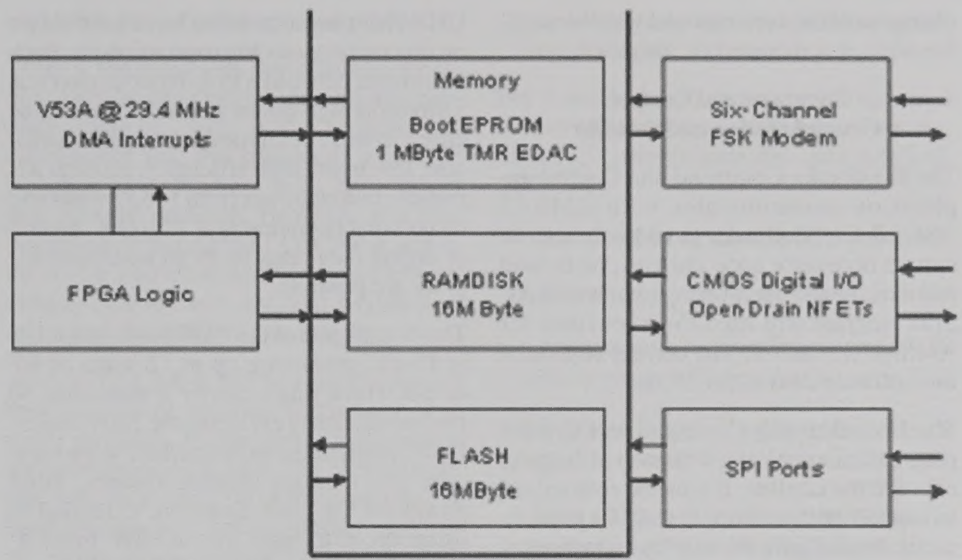


Figure 5. AMSAT OSCAR-E Central Processor Unit.

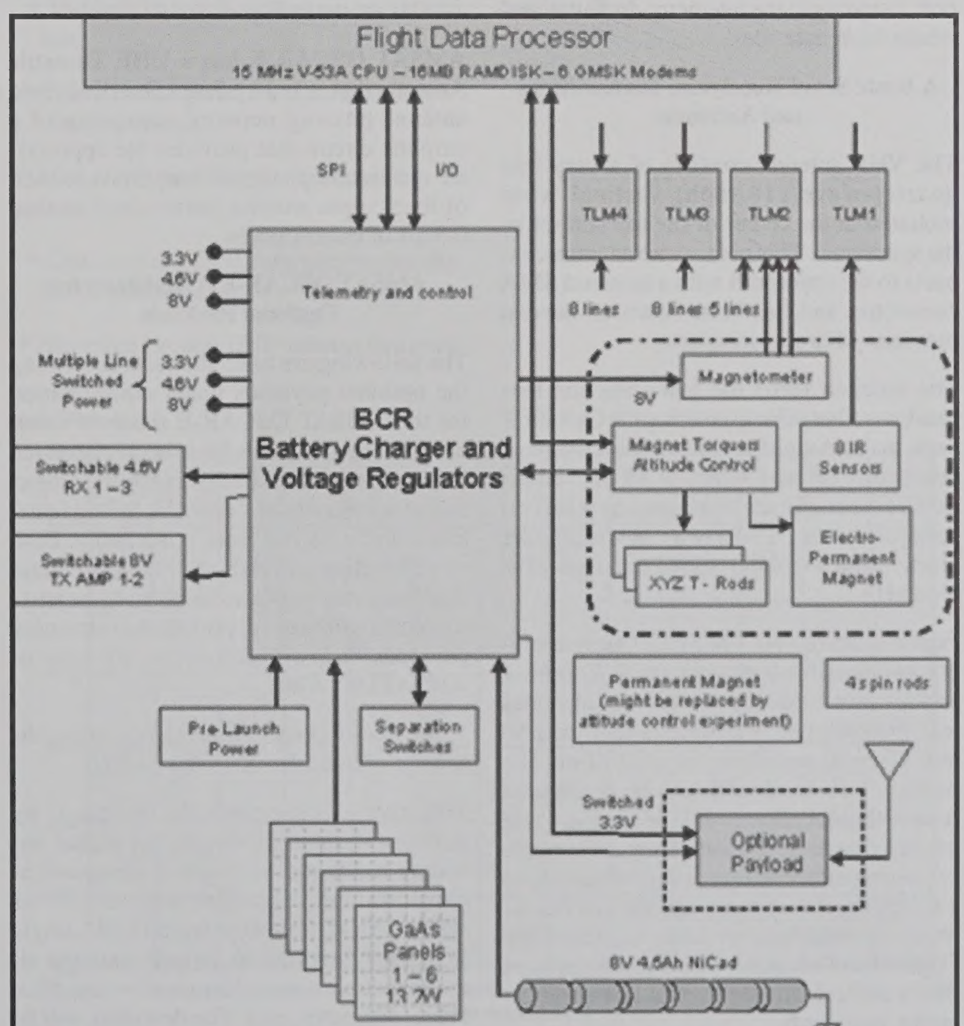


Figure 6. AMSAT OSCAR-E Power, Telemetry and Attitude Control Block Diagram.

charge satellite batteries and test the satellite while it is mounted on the rocket.

Command and Control: Ground Station and Satellite

The Bootloader Command and Control application communicates with AMSAT OSCAR-E's bootloader to allow the user to upload necessary code changes, or to load and execute the operating system and tasks. This program will need to be rewritten for AMSAT OSCAR-E. The current version of this software runs under DOS.

The Housekeeping Command and Control program communicates with each of the tasks onboard the satellite. It must be customized to support each additional task. Its primary use is to configure the satellite. The housekeeping command and control software is also currently DOS based.

The Telemetry Gathering and Reporting program is a standalone Windows application that will need to be developed for downloading and displaying satellite health information. This application would monitor a serial port, listening to the telemetry downlink and whole earth data files.

A Basic Set of Receivers, Transmitters and Antennas

The VHF antenna consists of a very thin quarter-wave (18-inch) vertical whip mounted in the center of the top surface of the spacecraft. This piano-wire antenna connects to the spacecraft with a standard SMA connector, and has been flown on several previous Microsat missions.

The antenna feeds the low insertion loss bandpass filter prior to entering the GsAsFET Low Noise Amplifier with a noise figure of less than 1 dB and a gain of 18 dB. Additional filtering is accomplished by a second bandpass filter. A four-way power divider channels the incoming signal into four VHF receivers

Four miniature VHF FM SpaceQuest receivers are used for both command & control and for user links. Each receiver consumes less than 40 mW and weighs less than 50 gm. Typical sensitivity is –122 dBm. The receiver's IF bandwidth can be configured prior to flight at either 15 kHz or 30 kHz, based on data rate requirements. They are capable of passing either analog or digital data up to 14.4 kbit/s. All of the receivers are fed directly into GMSK modems on board the Flight Data Processor. These receivers have flown successfully on several low-earth orbiting spacecraft.

AMSAT OSCAR-E has two SpaceQuest UHF FM transmitters that have been flown on several previous Microsat missions. Each transmitter contains a PLL-based exciter and a Motorola high-power amplifier. The unique characteristics of this design include its small size, low mass, high efficiency, on orbit adjustable output power from 1 to 12 watts and its nominal operation is at 7.5 volts. Analog or digital data rates up to 56 kbit/s and beyond are possible.

The overall gain of the UHF power amplifier is 39 dB, generating up to 12 watts of RF output with a single carrier at more than 60 percent efficiency excluding the 2mW exciter. Both transmitters can be operated at the same time into a single antenna system. High power on the UHF downlink is needed to offset the extra path loss at UHF frequencies balancing the VHF uplink. High downlink power will also permit transmissions at higher data rates and/or enable true handheld voice or data operation. The high efficiency reduces the heat generated and absorbed in the spacecraft and increases the useful life of the transmitter. The measured output of the UHF high power amplifier at 40°C is shown in Figure 7.

AMSAT OSCAR-E has a UHF Turnstile Antenna that is fed by SpaceQuest's hybrid antenna phasing network consisting of a stripline circuit that provides the appropriate quadrature phase and amplitude to each of four output antenna ports with less than 0.5 dB of insertion loss.

AMSAT OSCAR-E: Candidates for Optional Payloads

The following are brief abstracts describing the optional payloads under consideration for the AMSAT OSCAR-E mission. Other outstanding proposals have been suggested but were rejected in the first cut by the project team for a variety of factors including feasibility, value to the Ham community, cost, power budget and risk. It is almost certain that more cuts will have to be made because it is not possible to support all the remaining payloads on a single satellite the size of AMSAT OSCAR-E.

1. *Advanced Data Communications for the Amateur Radio Service (ADCARS)*

This payload supports the proposal by KA9Q and others for applying digital encoding techniques to improve communication links and bandwidth utilization. This system would use a wide-band TDMA single frequency data link to support multiple simultaneous users and modes (voice, data, video, telemetry, etc.). The downlink will be S-band, due to the bandwidth requirements. The uplink will be L-band if the single frequency TDMA wide-band uplink is implemented.

2. *L-Band/S-Band Communications System:* This payload, proposed by KA0ESA of AMRAD, describes a capability similar to that required to support the ADCARS experiment.

3. *GPS Receiver:* This payload was proposed by W3IWI and W2GPS. Unfortunately the NASA PiVoT GPS receiver that we had hoped to carry will not be available. If a receiver of the right size and low power requirement can be found, this payload will be re-considered.

4. *Active Magnetic Attitude Control:* This experiment has the potential for significantly improving the stabilization of the spacecraft. Several possible attitude control system (ACS) configurations will be investigated. The simplest ACS concept is to replace the permanent magnets with semi-permanent electromagnets. While physically passive, electronics are required to polarize and condition the magnetic rods. Another more involved ACS concept is to use three miniature torque rods for attitude control and a magnetometer for attitude determination.

5. *Audio Recorder Experiment:* This experiment, proposed by KK7P, will provide the capability for recording and playing back any audio channel. It is particularly useful in recording data from the multi-band receiver to support the low frequency experiment.

The ADCARS experiment team has recognized that, with minimal changes, the hardware for the Audio Recorder Experiment could also serve the ADCARS needs for computing resources.

6. *Low Frequency Receiver:* This experiment, proposed by AMRAD, uses the LF capability of the on-board multi-band receiver to study LF propagation phenomenon from the unique observation point above the ionosphere, particularly at 136 kHz.

The receiver and antenna whip are already on the spacecraft but a new E-field antenna interface amplifier and antenna-switching hardware will need to be designed if this project is to be supported.

7. *APRS:* This payload will provide a generic APRS digipeater to support and encourage mobile and handheld satellite digital communications. The target ground system assumes a user with a 9600-baud integrated TNC/Radio with an omni antenna, either an HT or a mobile. The spacecraft simply digipeats all UI packets addressed via the paths of APRSAT, RELAY or WIDE. The spacecraft digipeater does call sign substi-

tution like all APRS digipeaters and substitutes its own call after it digipeats the packet.

While it is not optimal for portable and mobile users, incorporating an APRS capability in the spacecraft can be done within the spacecraft basic bus, requiring no additional hardware, if 9600 FSK is used with VHF uplink and UHF downlink. The downlink will have to share bandwidth with spacecraft telemetry and other data downlinks. Some switching capability in one of the receivers may be required.

The implementation of APRS that is being considered would also allow for a *store-and-forward* mode, where copies of APRS packets are saved until the satellite is in range of a known APRS Internet Gateway station, when the APRS data can be downloaded at high speed on an encoded data link for high reliability.

8. PSK-31: Proposed by WB4APR, transponding using the PSK-31 technique can be accomplished using the communications capability of the basic spacecraft bus. Uplink would utilize 10-meter SSB reception through the multi-band receiver. Downlink would be via one of the UHF transmitters.

9. Multi-band Receiver/Antenna: Proposed by SpaceQuest, this receiver has already been tested in space and can provide a receive capability over a wide range of frequencies from LF through L-band. The development of the antenna is challenging and it is currently unclear if the broadband antenna would be optimized for LF/HF (through 30 MHz) or for VHF/UHF (10 meters through UHF) or both. A separate antenna will be provided for L-band.

10. High Efficiency Solar Arrays: Included in the SpaceQuest proposal to AMSAT, the additional power that would be made available for the experiments would clearly benefit the experiments. Efficiencies of up to 28 percent might be achieved using a combination of *flexible cells* with a new mounting and substrate design invented by SpaceQuest.

11. Robust Telemetry Link: This experiment would demonstrate the value of using FEC and interleaving encoding techniques to improve telemetry reception by ground stations. This technique was developed by Phil Karn, KA9Q and others for AO-40, where it is now being considered for implementation.

Summary

The core elements of AMSAT OSCAR-E are under construction now by SpaceQuest. The AMSAT OSCAR-E project team is working to finalize plans for the optional payloads.

There is the possibility that a launch opportunity might arise before the optional payloads could be ready. If this happens it is conceivable that the spacecraft would be launched as an *EasySat* only, with few, if any, optional payloads. However, it is considered likely that AMSAT OSCAR-E will be the first in a series of new low-cost LEO satellites, each to carry optional payloads of interest to the AMSAT community.

AMSAT OSCAR-E will be a step forward in the evolution of Microsat technology, with better receivers, higher power transmitters, and new operating modes. The user community will see a strong set of features from the basic satellite, even before optional payloads are added. These include:

- Analog operation including FM voice.
- Digital operation including high speed APRS.
- Higher downlink power.
- Multiple channels using two transmitters.
- Can be configured for simultaneous voice and data,
- Has a new multi-band, multi-mode receiver.
- Can be configured with geographically based personalities.
- Has a true circular UHF antenna that maintains its circularity over a wide range of squint angles.

For those with an interest in the technical infrastructure of the satellite there are significant improvements in AMSAT OSCAR-E:

- Faster and more capable IHU processor.
- Higher data rates on downlinks.
- Autonomous, self-healing, high efficiency power management system.
- Upgraded, highly capable, software package.
- Store and forward with continuous monitoring and geographically defined data forwarding.

These are only partial lists of new and improved capabilities. Notice that there are some tantalizing items in these lists that have not been explained in this article. They will be explored in future articles. AMSAT OSCAR-E is expected to be a very popular satellite. ■

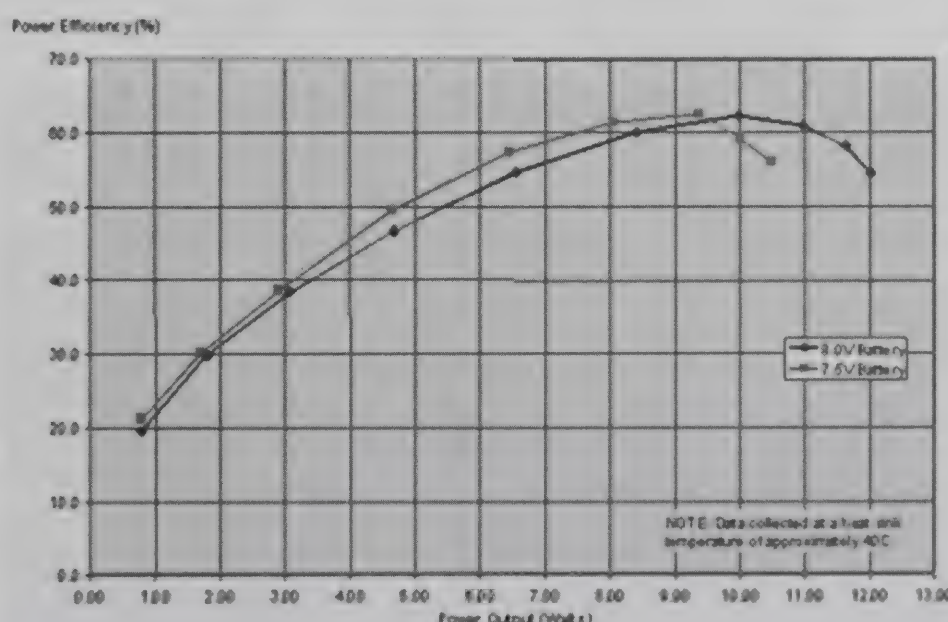


Figure 7. UHF Amplifier RF Power Output vs. Efficiency.

Portable Satellite Operation in Honduras

Bob Witte, KB0CY (*kb0cy@amsat.org*)

Figure 1. The FT-817 QRP transceiver, small enough to fit easily into a fanny pack, puts out 5 Watts on HF through 440 MHz.

The FM Low-Earth Orbit (LEO) satellites have enabled grid DXpeditions using very compact and portable equipment. A number of OSCAR enthusiasts make it a point to activate rare grid squares on UO-14 and AO-27. Other operators spend their time chasing new grids and running up their grid totals.

In February 2002, I found myself headed to a remote part of Honduras as a volunteer radio operator providing communications support for a medical team. This medical mission is part of the International Health Service of Minnesota (*http://www.ihsofmn.org*). Most of the medical communication was handled on 40M SSB using stations set up in *Field Day style* with temporary wire antennas and gasoline generators.

I took along one of the popular Arrow II 2M / 70 cm antennas and my Yaesu FT-817 QRP rig (Figure 1). A handheld FM HT would have been smaller but I had other reasons for taking along the 817, such as working some HF QRP. I would not have a lot of time to work the birds, but I hoped that I would catch a few good passes. Rather than lug my notebook computer and GPS receiver around, I chose to print out the satellite pass information and VHF grid-square for the locations that I would visit.

Figure 2. The Arrow II antenna compacts down into a roll-up carrying case.

The Arrow II antenna was the split-boom version with the duplexer built into the handle (Figure 2). It all rolls up in the optional carrying case, which I carried onto the airline flights. With increased airport security, I did have to unroll the dismantled antenna for inspection a few times.

The first stop on the trip was La Ceiba in grid EK65. A three-story hotel there was the main headquarters for the medical mission. I found easy access to the roof and a good unobstructed location to operate from. Using the callsign HR3/KB0CY, my first contact was with Jerry Brown, K5OE on a UO-14 morning pass. I worked a number of other stateside stations along with XE2AT and HC5SF on UO-14 and AO-27 that morning.

A few days and a couple of airplane rides later, I was in the remote eastern part of the country near Puerto Lempira (EK85). I caught several evening passes of UO-14, working KO4MA, XE1MEX, KE4AZN, KK5DO, W5BTS, N5AFE and others. The evening passes almost got routine, standing out in the dark swatting mosquitoes waiting for UO-14 to rise in the south. With limited operating time, I focused only on the best satellite passes. Also part of the routine was that the satellite would start out pretty quiet, then I'd hear a few Latin American stations, then a few stateside. After the satellite passed overhead, my signal would get lost in all of the stateside uplink congestion. I could hear stations in Canada but I couldn't seem to work them.

My friend Denny Bueschin, KB9DPF did the logging duties for me, standing with a clipboard and his headlamp, jotting down callsigns. Normally, I would have brought along an audio tape recorder but on this trip I was traveling as light as possible. The kids from the local village were curious about everything the medical team did and pointing a radio antenna at the sky was no exception (Figure 3).

After the medical mission was over, Denny and I took a few days to relax out on Roatan Island, a popular dive and snorkel spot. Here my callsign was HR6/KB0CY and the grid was EK66. A few days later and it was time to catch a flight back to the US.

This was certainly not the first grid DXpedition for the FM birds, nor was it the most notable. However, it was a good opportunity to add some OSCAR operation to

my trip and make a few contacts from some rare grid squares. Over the two weeks that we were there, we worked 11 satellite passes, making 52 contacts. Thanks to all of the radio amateurs that took the time to work us from HR land. ■

Figure 3. The children from the village observe Bob Witte, HR3/KB0CY working UO-14.

Setting Up for AO-40 L-Band Uplink

Mike Kingery, KE4AZN (*ke4azn@amsat.org*)

Since my first contact on AO40 with Reinhard Richter, DJ1KM, on 09 May 2001, I have enjoyed working the bird with the U band uplink. I really liked talking with the operators using the L band uplink and admiring their fine signals. That started me thinking that it might be fun to get things setup in that direction. I then had the opportunity to meet and work with Jim White, WD0E and Bdale Garbee, KB0G of the RUDAK command team on a couple of small projects. And wanting to help Jim with the downloading of experimental data made me finally decide to get things working on L-band.

So, what to do when having absolutely nothing capable of being used on L-band? Well, to make a long story short I purchased an Icom 910H with the optional L band module. I had Dave Clingerman, W6OAL of the Olde Antenna Lab (see references), build me a helix feed for L-band to mate to a 3 ft surplus dish that I had acquired. Even with the modest 10 watts output from the 910H running into 35 feet of LMR400 to that three foot dish I was able to put a signal into the bird. And I could copy it! I held a couple of QSOs with stations that could really copy the bird well. It was obvious, and not a surprise, that I would need a little more power to put and really good signal into AO-40. And I knew it would take a good bit more power to work the RUDAK system on 9600 baud. So it was amplifier time.

I looked around a bit at different amps that were available and ended up selecting a DL2AM 80 watt amplifier kit. Philipp's kit looked easy to build, which was a big plus for me. Also, they are available here in the US from K5VH (see references). Everything needed component-wise to build the kit is included. The only items that I supplied to complete the kit were heatsink compound, solder, and time. After looking over the parts and instructions, which include some notes from K5VH, that help in the translation greatly, I got started.

The first step in assembly of the kit is to solder the PCB to the enclosure sides. This had me concerned since my Weller soldering iron is only 40 watts. But with a rather large flat bladed tip I was able to accomplish the task without too much difficulty. It might not be the prettiest soldering job, but it did work. The PCB is attached to the heatsink assembly to place the enclosure in the correct position before soldering. Figure 1 shows the top side of the PCB soldered to the enclosure. The N connectors were added to the enclosure and soldered to the PCB next. More discussion later on the N connectors. Next came the hybrid amps, which are mounted to their individual heatsink blocks using that wonderful white stuff and attached to the bottom side of PCB with 3 screws for each block. Figure 2 shows the bottom side with 2 of the 4 hybrids mounted in place. The next task is to solder the hybrids and the other top side components in place. This task is relatively easy and there are not that many parts to attach. Another plus for this kit. Figure 3 shows the top side after installing the components. The only thing left now is the power feedthrus on the side of the enclosure.

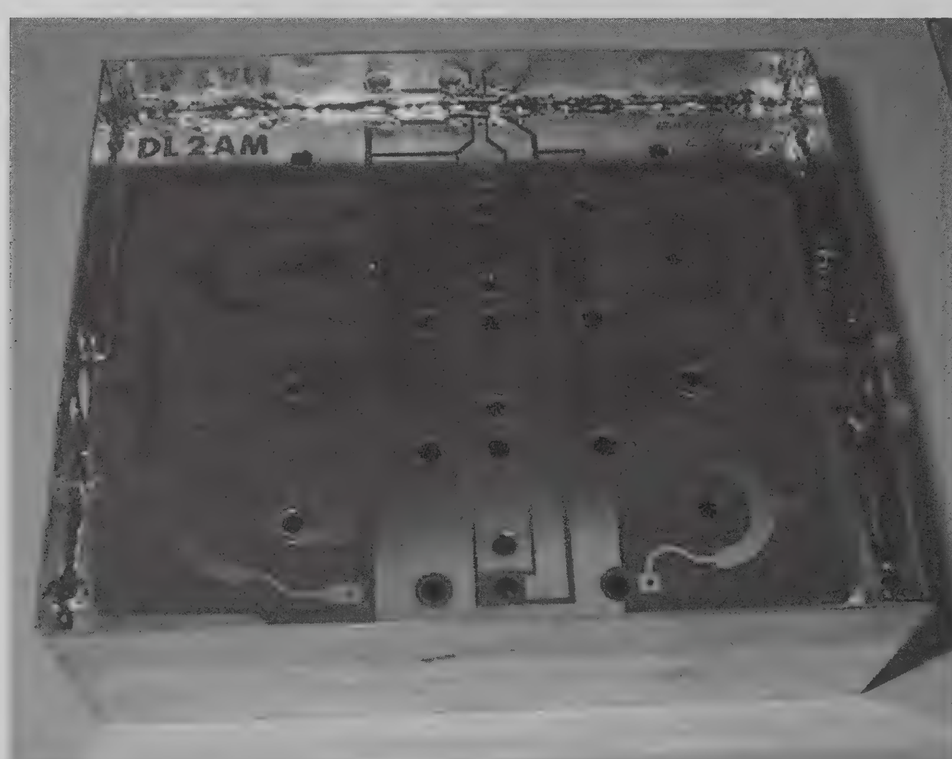


Figure 1: Topside of PCB soldered to enclosure

It took me about 4 hours to build the kit. And I am very slow. Having done one it would only take half the time to build another one. Overall the construction is very easy. The few surface mount components are not piled in on top of each other so there is plenty of room to work.

Being limited in my test equipment there is not much I could do. I checked the regulator output and did the required smoke test and that was about it. And luckily for me I kept all the smoke in. So, time for the acid test. My kit needs about 1.8 watts of input power to achieve the full rated output for the hybrids. Needless to say the 10 watts from the 910H would be too much. And knowing the operator as I do, he would eventually mess up and leave the power knob turned up after working another bird. So, off to find some attenuation, with some left over coax. After plundering through all my junk lying around the shop, nothing would kill enough signal. I can't believe I was actually trying to reduce the power available. I finally found the perfect section, attached to my G5RV. So much for that antenna. I was able to get my output down to 1.5 watts, which I felt was fine, as I certainly would not over drive the amplifier with that. I placed the feed in the backyard and powered everything up. I measured approximately 65 watts output from the amplifier.

With everything checked out and ready I prepared for the first on air test. Kevin Schuchmann, WA6FWF and I setup a schedule for early morning on AO-40. After a little difficulty finding my downlink things proceeded well. During that test the bird was just coming out of perigee so signals were very good. I varied the power output from the amplifier and the audio quality never changed. It was very clean and crisp, with

no distortion. We decided to give it another test on the next day with the bird at a greater range. Again signals were good and we had a nice roundtable going, and were joined by a few European stations as well. Overall it was a great morning on the bird. With DX calling us for once!

I did notice during the first day that the base plate of the amplifier was getting very warm. The recommendations are for that temperature not to exceed 50ºC. That evening I decided to mount a heatsink to the base to help dissipate some heat. The heatsink is shown in Figure 4. A small cooling fan has also been used to blow air across the fins of the heatsink. I placed a temperature strip on the base plate to monitor the temperature the next day. With the heatsink and cooling fan in place I was able to keep the temperature, while operating SSB at a moderate power level, around 40ºC or less. I was pleased with the addition.

I had the opportunity to get on AO40 another day when the range was even greater. With a squint of about 23 degrees, at MA136, I was able to work Reinhard Richter, DJ1KM, with the L band uplink. My signal was not all that strong but we had a nice QSO and I was very pleased to make the uplink at that range.

In general with moderate squints, <15, I can run the amp at approximately 20 to 30 watts output and put a good signal into the bird. With the loss in the coax I may be getting something in the range of 13 to 20 watts at my feed. With my small transmit antenna, that works out to be only about 800 W ERP, but I am sure the circular polarization of the helix feed helps my signal somewhat.

My completed setup for L band uplink starts with an Icom IC-910H. Including the optional L band module. I run the output through some old coax, which reduces the rigs output power to 1.5 watts. I measured 65 watts output from the amplifier in this configuration. The amplifier output is connected to a Diamond SX-1000 power meter to keep an eye on my power level. The coax run out to the helix feed is 35 ft of LMR-400. The helix feeds a 3 ft, offset fed, Channelmaster dish. Figure 5 shows the two dish antennas that I am using for AO40. The Channelmaster is on the right with the L-band helix feed. The BBQ grill dish on the left is for S band downlink. It is covered in screen door wire mesh. I am using a helix feed, Downeast Microwave Preamp, and a modified 3733 TSI downconverter for the S-band receive side.

One minor addition I intend to make is to strengthen the N connector mounting. I plan

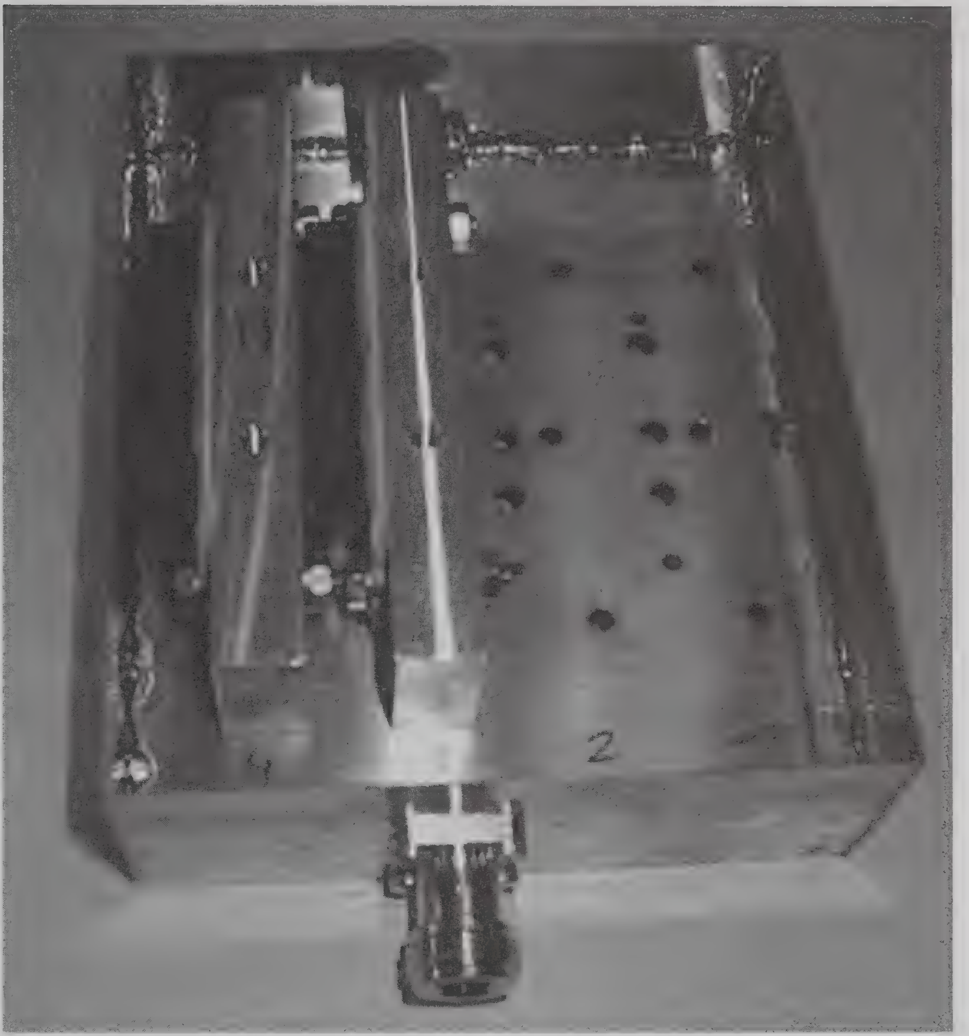


Figure 2. Bottom side of PCB with amps and heatsinks shown.

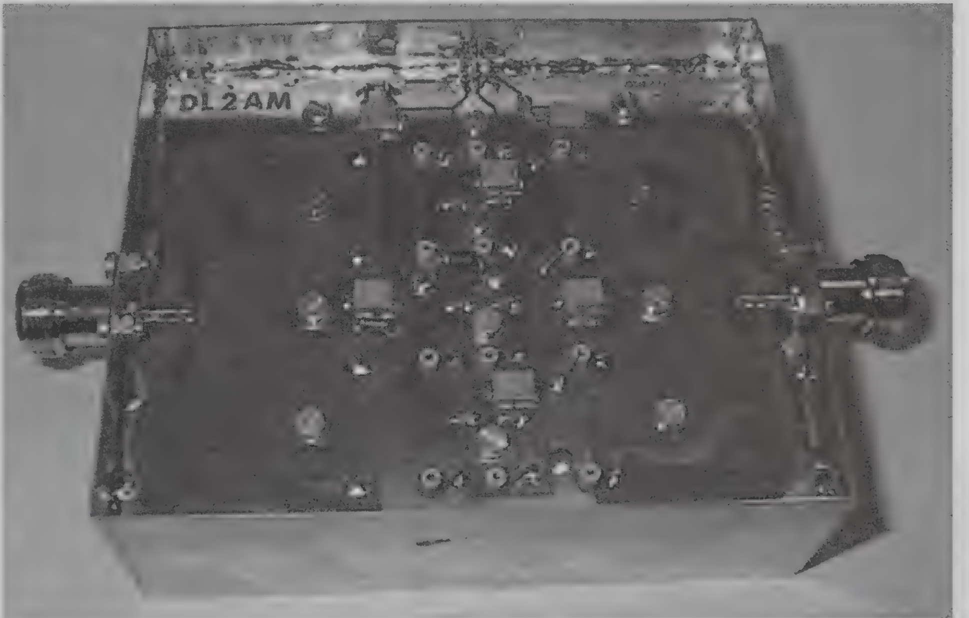


Figure 3. Top side after component installation.

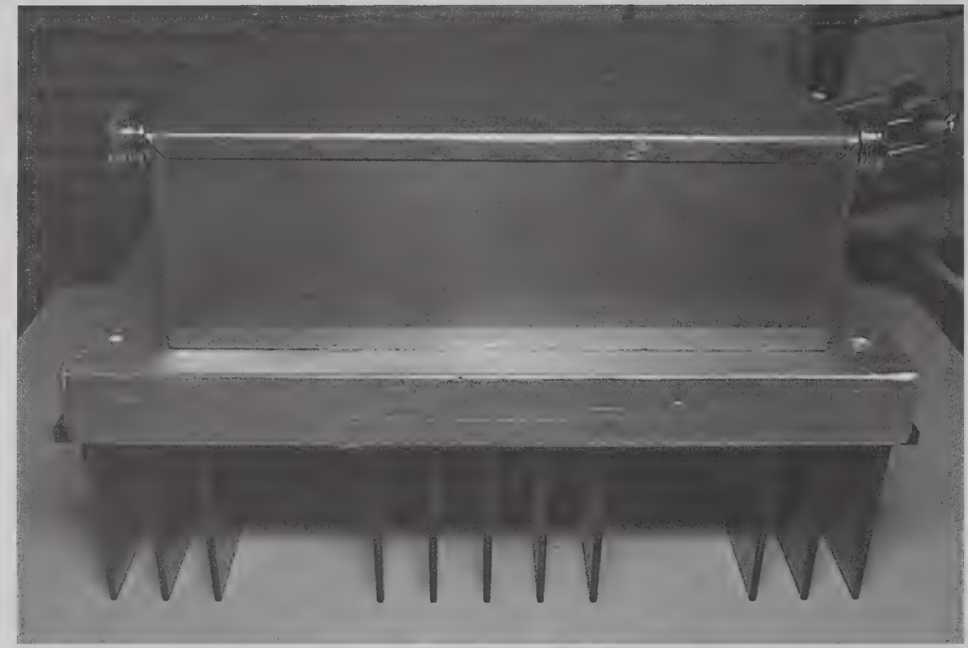


Figure 4. Heatsink added to base plate.

Figure 5. KE4AZN Satellite Antenna Farm.

to add a small bracket to each connector to act as a strain relief, and place any load from the cabling on the base plate. With less rigid coax than I am using that probably would not be necessary. Also, the amplifier is not housed in a weatherproof enclosure. It would need to be mounted in an enclosure if positioned at the antenna. I plan to keep the amp in the shack if at all possible.

Overall I really enjoyed putting the L-band station together and getting it on the air. So, if you hear me on AO-40, please drop by and say "hello."

Reference List

1) DL2AM, Philipp Prinz, WWW site: *http://www.dl2am.de/*

2) Tom Haddon, K5VH can be reached at *k5vh@texas.net*

3) Dave Clingerman, W6OAL of the Olde Antenna Lab, can be reached at *w6oal@aol.com*

4) KE4AZN's WWW site at *http://downtown.ala.net/~mkingery/* contains more pictures of the amplifier kit and other station related items. ■

AMSAT OSCAR 40's Doppler Frequency Shift

By Franz Bellen, DJ1YQ

Translation from the *AMSAT-DL Journal* by John J. Bubbers, W1GYD

The Doppler effect, named after its discoverer Chr. Doppler, 1803-1853, can present great difficulties in satellite communications. A physical description of the Doppler effect will not be presented here nor a further explaination of the mathematical relationship that is required for the discussion. The value limits of the Doppler shift will be presented as they can occur anywhere on Earth for AO-40's orbit (limit value consideration). Also, an uplink related frequency could be determined in Mode S for an actual received frequency on 2400 MHz.

The Mathematical Relationship

The Doppler shift, df, of a signal is

$$df = f - f_o = -(v_s/c) * f_o \qquad (1)$$

In which:

df = Doppler shift

f = received frequency

f_o = radiated frequency

v_s = satellite velocity relative to the QTH of measurement

c = light velocity constant

The satellite velocity is computed as follows:

$$v_s = (d(t_B) - (d(t_A))/(t_B - t_A) \qquad (2)$$

In which:

t_A = time at start of measurement

t_B = time at completion of measurement

$d(t_A)$ = distance to the satellite at t_A

$d(t_B)$ = distance to the satellite at t_B

Formula (1) demonstrates that the Doppler shift is proportional to the frequency and the satellite velocity, which means that the shift on 13 cm is about six times as large as on 70 cm, and at perigee it is larger than at apogee.

Since the satellite velocity is negative on approach the Doppler frequency shift is positive and the RX frequency is higher than the satellite's radiated frequency. At the least distance difference change between satellite and received location, the shift value is 0, and then becomes negative.

Limit Values of Doppler Shift

There is no need to calculate the variation of the AO-40 orbital path from the driving force on the satellite beyond the immediate information. The orbital path will now be influenced only by the gravity of the earth, the sun and the moon. The most interesting orbital parameters are:

- the inclination i
- the perigee height hp
- the perigee angle g

Figures 1 to 3 show the progress of these values for the coming 20 years. The orbital time P was assumed to be a constant at 1147 minutes. For amateur use the error is negligible.

What do the Figures Illustrate?

Figure 1: The satellite's inclination has not been changed since the launch. It is the latitude value of the geostationary orbit in degrees, which corresponds to the rocket launch locale. The value of i will change between 5 and 10 degrees because of the previously indicated applied forces. The higher the inclination the higher the maximum el-

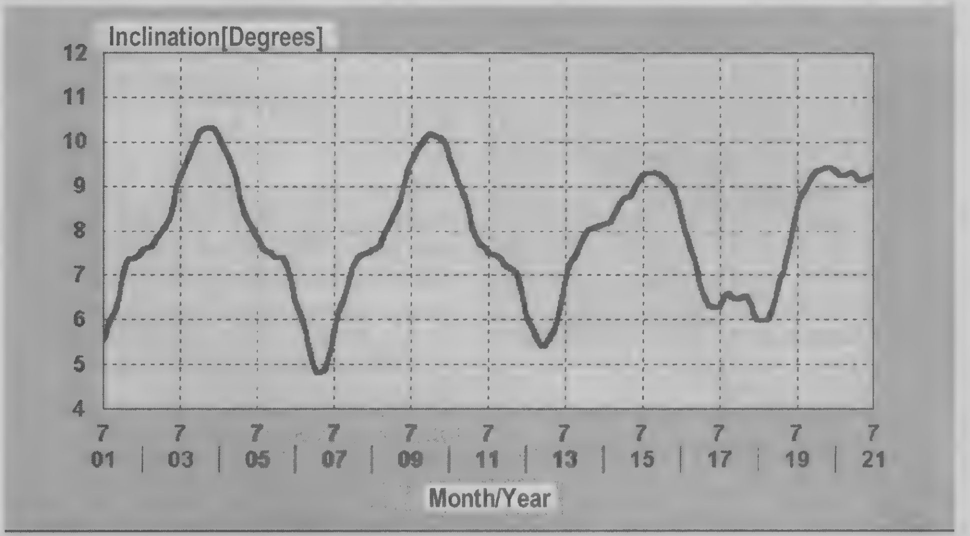


Fig. 1: AO-40 Inclination Change over 20 Years.

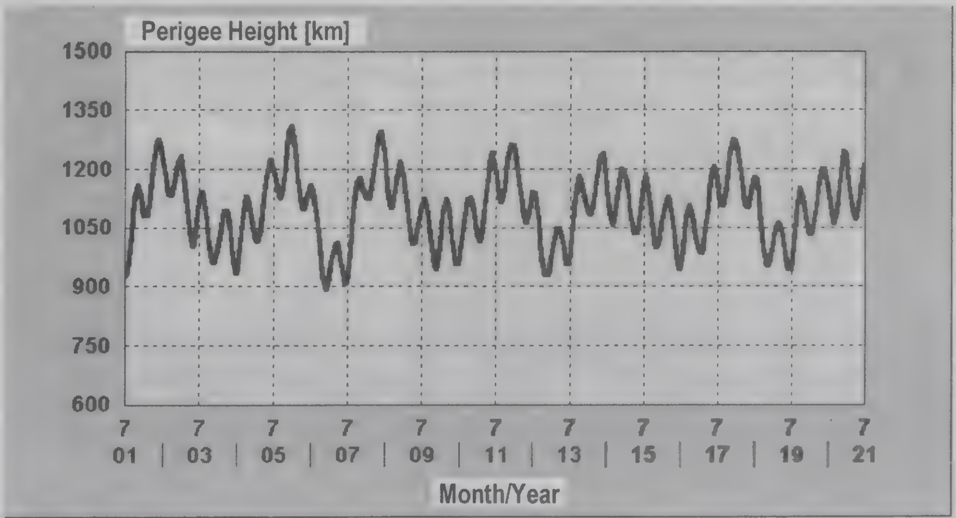


Fig.2: AO-40 Perigee Height Change over 20 Years

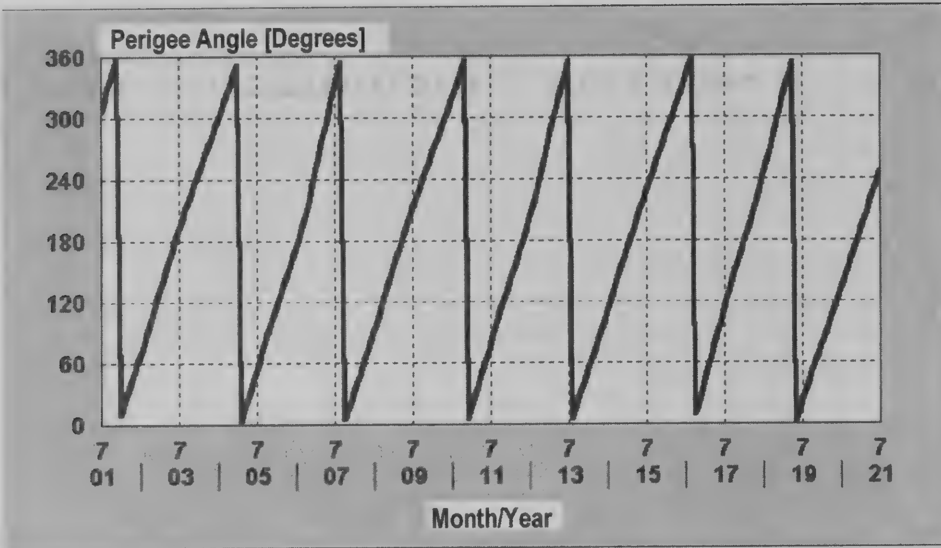


Fig. 3: Perigee Angle Change of AO-40 over 20 Years

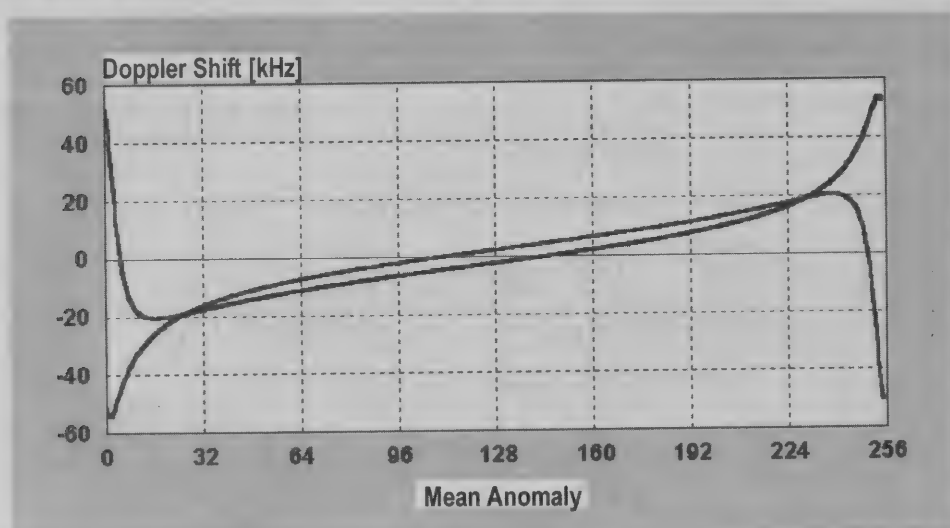


Fig. 4: Maximum Doppler Shift for Mode-US

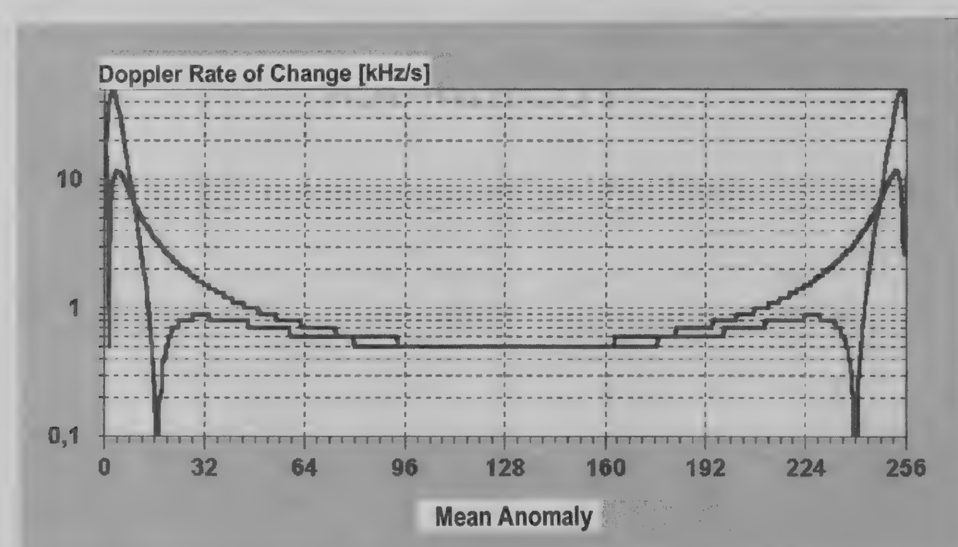


Fig. 5: Maximum Doppler Rate of Change for Mode-US

evation of our antennas will become.

Figure 2: The most important thing we can get from this figure is that AO-40 will not re-entry early like AO-13. The orbital path is stable and similar to that of AO-10. The height at perigee (hp) varies between 900 and 1300 km over the course of 20 years. The height at apogee (ha) varies by 400 km during that same period. The median value is 58720 km.

Figure 3: The perigee angle traverses 360° every three years. This means that the satellite's orbit will have rotated around the earth's cent er in this time period. During this interval there will be times when we cannot "see" the perigee or apogee. If g = 270° the apogee is optimum for the northern hemisphere, at 90° for the southern hemisphere.

The average values of the curves from Figure 1, i = 7.86°, and Figure 2, hp = 1098 km were used for the calculation of the maximum Doppler shifts. The calculations were made for Mode- US, 70 cm uplink, 13 cm downlink. The earth's rotation was taken into account, and since they are in the same direction, the Doppler shift of AO-40 is minimized. Figure 4 shows the results of the calculations. They do not consider the Doppler shift at a specific location (QTH), rather these are the limit values that can occur at the immediate mean anomaly in the orbital plane. The figure shows that the shifts are in the order of ± 55 kHz close to perigee. Since our locations do not lie in the orbital plane = > ±7.86° either northern or southern latitude, we will not reach these maximum values. Further it can be learned from Figure 4 that during long time periods the Doppler shift is very small at the apogee. Considering Figure 5 which displays the Doppler shift per second or rate of change from Figure 4, the up- and downlink frequencies have to corrected very infrequently.

Close to perigee they are quite different. Here the changes can be a maximum of 50 Hz every second. The value is valid for QTH's in the orbital plane. At our latitudes we will reach a maximum of only 60% of the maximum values, that is 33 kHz, a shift rate of change 30 Hz/s. A computer controlled Doppler correction is appropriate in any event. Because of the inverting operation of Mode-US the Doppler shifts and slopes are smaller than on 13 cm but larger than on 70 cm. For the 13 cm beacon frequencies Figures 4 and 5 must be corrected as follows:

(Beacon frequency shift)/-slope = (read out value) * (beacon frequency)/(2401-436) (3)

The maximum shifts and slopes can be similarly calculated for Mode LS. The relation-

ship is linear, only the beacon frequency factor has to be replaced.

Calculation of the Actual Uplink Frequency

A method is proposed by which to calculate the actual uplink frequency for a station to be answered. The system is also transferable to Mode-LS. The S-2 transponder has the following frequency range on Mode-US (DL6DBN information):

Uplink: 435780 to 435495 kHz

Downlink: 2401210 to 2401495 kHz

The sum (uplink + downlink) for the passband beginning or passband ending is:

C2 = 2836990 kHz,

considering inverted operation. For S-1 transponder operation it amounts to:

C1 = 2836030 kHz

From this it is easy to see that the downlink frequency of a heard station, has to have an uplink related frequency C2 relative to C1 minus the downlink frequency, if the Doppler shift were not present, and which actually runs counter to it. A Doppler shift correction must be introduced (Doppler13 – Doppler70). Presented in a formula it appears as follows:

C2,C1 = Uplink frequency + Downlink frequency – (Doppler13 – Doppler 70) (4)

The actual uplink frequency can then be arrived at as follows:

Uplink frequency = C2,C1 – Downlink frequency + (Doppler13 - Doppler70) (5)

An Example

Assume that you would like to answer a station on 2401350 kHz. The computer indicates a shift of 34.890 on 13 cm and a shift of 6.329 kHz on 70 cm. The transmitter frequency for the uplink is then:

Uplink frequency = 2836990 kHz –2401350 kHz + (34.890 kHz – 6.329 kHz) = 435668.561 kHz.

Since it is very inconvenient to use a pocket calculator in addition to operating the equipment, it is advisable to have the computations performed on the available computer, since the Doppler shift values are already available for 13 cm and 70 cm. If it shows the downlink frequency on a continuing basis, it can also show the respective uplink frequency continuously. Setting the frequency could be done automatically, however it is not a good idea, since the frequency drift of the 13 cm converter could introduce an error of several kHz. The author uses this method with great success.

A 13 cm converter is often used with an output frequency of 144 to 146 MHz, so the following considerations should be made in the calculations (see the previous example):

The downlink frequency of 2401350 kHz is shown as 145350 kHz by the 2 meter following system, so that 2256000 kHz are missing. The computer must add 2256000 kHz to the 145350 kHz reading. The formula (5) then appears as follows:

Uplink frequency [kHz] = C2,C1 – (Downl.2m + 2256000) + (Doppler13 – Doppler70) (6)

It is important to note that all values must have the same dimension, kHz in this example.

Summary

AO-40 is one of the most interesting satellites that amateurs have ever had. It has something for everyone:

- World wide SSB operation because of its great apogee height
- Performance of software experiments, see Sections 4 and 5 among others,
- Performance of hardware experiments. The 13 cm antenna experiments are espe cially notable.

It is desirable to become familiar with the method for answering other station. Determining the equivalent uplink frequency is difficult for the newcomer. Only at the perigee is the Doppler shift large. Computer controlled compensation is appropriate at that time. Hours before and after apogee there are no problems in using manual compensation. ■

Considerations, Tips and Measurements for S-Band Reception of AO-40

Klaus H. Eichel, DL6SES and Hans-L. Rath, DL6KG

Translation from *AMSAT-DL Journal* by John J. Bubbers, W1GYD

The reception of AO-40 transponder operation was reported in a previous article [1]. The station at DL6KG was set up early for mode LS for the original launch date.

Operation on AO-40 with a convenient short backfire antenna showed that only CW would be possible; for SSB phone this downlink antenna would not be adequate for good radio communication. Freddy de Guchteneire, ON6UG determined in his test prototype that a gain of 18 dBi was needed with a tolerance of 1 dB [2].

Just before the start of winter weather the 60 cm parabolic reflector was installed with the Patch driver from G3RUH (thanks to DL6SAQ) and the MKU-24-TM-OSCAR converter from Kuhne Elektronik. This quickly indicated that this was the right thing to do: AO-40 was as easy to work as previously on AO-10 and AO-13.

Antenna

For reasonable reception of the 2.4 GHz downlink signals from AO-40 a G/T ratio of at least 1 is needed in the receiving equipment, for example, a gain factor of 100 (equivalent to 20 dBi) and a system noise temperature of 100 K, thus $G/T = 100/100 = 1$. The gain is referenced to an isotropic radiator, whereas a parabolic 60 cm diameter reflector on 2.4 GHz has a gain of approximately 21 dBi (or a gain factor of 125).

The noise temperature of the receiving system is the sum of all the noise temperatures that have an influence. The following items belong among the determining factors:

- the antenna temperature, about 30° to 40° K
- the noise temperature of the receiver, in cluding the preamplifier, typically 60° to 70° K
- the noise temperature of the cable between the antenna and the preamplifier/converter, with a target of zero, or absolutely no cable.

The measured 60 cm Parabolic Reflector with Patch Driver

In installations for receiving signals from space, the ratio of antenna gain to total noise temperature has been established as a unit of measure [3]. We, as satellite users, should perhaps become used to this unit of measure. At the very large apogee distance of AO-40 and the relatively small amount of radiated power from the transponder we require a G/T ratio of at least 1 for "good" reception. Decisions on the use of G/T values indicate that antennas for 13 cm parabolic reflector reception diameters of 60 cm to 1 m are well suited (beamwidth of 15 to 9 degrees); at larger diameters the mechanical drive and aiming precision become more demanding (moving mass and accuracy). At the AMSAT-UK Colloquium Jerry Brown, K5OE reported on his various experiments on helical antennas [3], which he abandoned in frustration and changed over to a parabolic reflector.

Converter

The converter (preamplifier) should be connected directly to the driven element, because any cable unnecessarily increases the noise temperature. The noise output signal level should be at least 13 dB above that of the following stage, because the S/N loss is less than 0.25 dB and can be ignored. A 2 m receiver typically has a noise figure of 6 to 8 dB, which means that we need a minimum noise power of 20 dB at the output of the converter (above the noise of a 50 Ohm resistor). Since the antenna with preamplifier has a noise of 100 K, and is this is about 5 dB less than a resistor at room temperature, we need a total amplification of 25 dB and additional amplification in the magnitude of the cable loss (preamplifier/converter to the following stage); this leads us to a minimum of 26 to 27 dB at 1 to 2 dB of cable loss. In critical cases this cable should be double shielded to prevent signal breakthrough from local 2 m stations (use RG-214 for instance, or Aircell-7 among others).

These opinions were confirmed by laboratory measurements as follows. The measure-

ments were made with a noise measurement system HP-8970A and the HP-346A noise generator (5.5 dB ENR). The measurements had the advantage that this noise measurement system has a self-noise figure of 6 dB, the typical value of a 2 m transceiver. We measured a noise temperature of 50 K with a direct connection of the converter to the measurement apparatus. By connecting a 3 dB loss device between the converter and the noise measurement system the noise temperature was increased by 1 K to 51K total, which is equivalent to quite a long cable of about 35 meters of RG-214; this means that for a typical total noise figure for a complete installation of 100 K the noise temperature would be increased to 101 K, about 1% (or 0.05 dB).

Measurements

DJ1YQ's AO-40 measurement results were published in the *AMSAT-DL Journal* [4]. These were fully verified in December 2001 by DL6KG using a Tektronix spectrum analyzer TEK-2710. The use of an analyzer better shows the band occupancy and is easier to evaluate than the presentation from a panoramic display, since the analyzer has an adjustable video filter. The satellite at the measurement time was virtually at the apogee, at MA from 130 to 136. The squint was at 8°, and the elevation was about 35°. The S2 downlink band was observed.

1.) The middle beacon, from which all data were collected, was *visible* at about 15 to 18 dB above the noise (after 16 bit digitizing in the analyzer) and very uniform. Both sidebands were easily recognized, as well as the third order sidebands. The loudest SSB signals had a peak value as strong as the beacon. The transponder noise was barely noticeable (-119dBm), at a ground noise of –120.5 dBm (bandwidth 2.4 kHz).

2.) The AO-40 command team has made the recommendation that the uplink power should be set so that the signals are 8 to 10 dB below the level of the S2 beacon signal. According to these measurements and those of DJ1YQ 5 dB lower would instead be better, because the HF power of a well-processed SSB signal is 10 dB below its peak value (PEP). Experience shows that knowledgeable radio amateurs can read SSB signals when the HF power is as strong as the noise or when the peak noise difference is 10 dB. For CW a much smaller uplink power is naturally adequate.

3.) Directing the parabolic reflector to the horizon resulted in –115 dBm (bandwidth 2.4 kHz) input signal and at the zenith –120.5 dBm, or a difference of 5.5 dB. This value pleased the system's operator, because a good measurement resulted with the commercial (and frequently checked) measurement system, while until now only S meter derived values were available.

4.) Sun noise measurements were not obtainable, because the winter's day the sun was already too close to the horizon and the warm earth interfered with measurements.

With these kinds of measurements when CW carriers are compared to the noise there can be errors of several dB. In our receivers the normal detectors that drive our S meters deviate and lead to incorrect noise values, which can affect the measurement of the signal/noise value of the beacon signal [3].For those who want to make more precise measurements, the receiver AVC/AGC has to operated disabled and a volt- or watt meter connected to the audio output, which can truly show the effective value. A resistive loss pad can be used in the antenna circuit to make measurements; if the AVC/AVG control cannot be disabled the HF control can be turned down.

Suggestions for the Testing of a 13-cm Receiver Installation

1.) When turning on the preamplifier/converter there is a noise increase of at least 13 dB. This gives an indication of the condition of the preamplifier and the converter.

2.) When moving the antenna between the (warm) earth and the zenith (cold) there is a difference of about 5 dB. This will establish the noise temperature of the installation. Setting the elevation to zero degrees is not adequate, -10° and in the direction of a meadow or bushes, but not in the direction of a smooth, reflecting surface or a building satisfactory. Unfortunately, many rotators cannot be set below the horizontal position.

3.) By directing the antenna toward the sun the noise should increase by 2 dB or more when compared to the direction of the cold sky. This reference is not especially exact, since the noise varies from time to time; if the flux values at the time of the measurements are used, the time and value of the flux measurement should be noted and recorded (from the beacon DK0WCY on the internet www.dk0wcy.de). This will roughly establish the G/T ratio. Especially to be noted is that measurement 2.) can be valid, but the receiving setup is quiet, if measurement 3.) is not the right value.

References

[1] *AMSAT-DL Journal*, Nr. 3Jg. 28 Sept./Nov. 2001, Page 28 Stimmenn zum ersten AO-40 Transponderbetretrieb im Mai 2001

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[3] G.R.Brown, K5OE,>>Y.A.H.E.<<(Yet Another Helix Experiment) AMSAT-UK, *Proceedings of the 16th Colloquium, Univerity of Surrey*, July 2001, Seiten 89-93

[4] Beobachtung der Downlink-Signale von AMSAT-OSCAR-40, Franz J. Bellen, *AMSAT-DL Journal,* Nr. 4, Jg 28/29, Dez./Febr. 2001/2002, S. 15-17 ■

2002 AMSAT Field Day Competition

Bruce Paige, KK5DO

It's that time of year again; summer and Field Day! Each year the American Radio Relay League (ARRL) sponsors Field Day as an emergency preparedness exercise. The event takes place during a 24-hour period on the fourth weekend of June. For 2002 the event takes place during a 27-hour period on the fourth full weekend of June, from 1800 UTC on Saturday, 22 June 2002 through 2100 UTC on Sunday, 23 June 2002 (with a limit of 24 consecutive hours). The Radio Amateur Satellite Corporation (AMSAT) promotes its own version of Field Day for operation via the HAMSATS, held concurrently with the ARRL event.

If you are considering *only* the FM voice satellites like UO-14 or AO-27 for your HAMSAT Field Day focus, don't, unless you are simply hoping to make one contact for the ARRL rules bonus points. The congestion on UO-14 and AO-27 was so intense during Field Day 2000 that some stations running over 100 Watts on the two-meter uplink to high-gain Yagi antennas could not make a single contact. Therefore, a repeat the one-QSO-per-FM-satellite rule will be in effect this year, as this plan worked so well in 2001. However, we are going to add the International Space Station to the one QSO limit. You will be allowed one QSO if the ISS is operating Voice. You will also be allowed one digital QSO with the ISS and PCSat.

The format for the message exchange on the ISS or PCSat packet is an unproto packet to the other station with all the same information as normally exchanged for ARRL Field Day:

W6NWG de KK5DO 2A STX

KK5DO de W6NWG QSL 5A SDG

W6NWG de KK5DO QSL

If you have worked the satellites on Field Day in recent years, you may have noticed that a lot of good contacts can be made on some of the less-populated, low-earth-orbit satellites like FO-20, FO-29 and RS-12/13. During Field Day the transponders come alive like 20 meters on a weekend. The good news is that the transponders on these satellites will support multiple simultaneous contacts. The bad news is that you can't use FM, just low duty-cycle modes like SSB and CW. AO-10 can also be a lot of fun on Field Day if the solar panels are properly illuminated and it is in a good position in the sky for Field Day. And, of course, the big news this year is AO-40, expected to be very, very popular. Plot some orbits and check it out.

THE 2002 AMSAT Field Day Rules

The AMSAT Field Day 2002 event is open to all Amateur Radio operators. Amateurs are to use the exchange as specified in ARRL rules for Field Day. The AMSAT competition is to encourage the use of all amateur satellites, both analog and digital. Note that no points will be credited for any contacts beyond the ONE allowed via each single-channel FM satellite. Operators are encouraged not to make any extra contacts via these satellites (Ex: UO14 & AO27). CW contacts and digital contacts are worth three points as outlined below.

1. Analog Transponders

• Each satellite transponder is considered a separate band.

• All phone QSO's and all CW QSO's on a given satellite transponder are considered separate bands. - All packet/RTTY/ASCII/AMTOR QSO's through analog transponders are counted as CW QSO's for scoring purposes. - Phone QSO's count for one point and CW QSO's count for three points. - Cross-mode (CW/phone) contacts are not allowed. - Only one contact is allowed via each single-channel FM satellite, UO-14 (1 phone), AO-27 (1 phone), ISS (1 phone and 1 digital), PCSat (1 digital). - The use of more than one transmitter at the same time on a single satellite transponder is prohibited.

2. Digital Transponders

For the Pacsats (LO-19, UO-22, etc.), each satellite is considered a separate band. Do not post "CQ" messages. Simply upload ONE greeting message to each satellite and download as many greeting messages as possible from each satellite. The subject of the uploaded file should be posted as Field Day Greetings, addressed to ALL. The purpose of this portion of the competition is to demonstrate digital satellite communications to other Field Day participants and observers.

The following uploads and downloads count as three-point digital contacts.

(a) Upload of a satellite Field Day Greetings file (one per satellite).

(b) Download of Satellite Field Day Greetings files posted by other stations. Downloads of non-Field Day files or messages not addressed to ALL are not to be counted for the event. Save DIR listings and message files for later "proof of contact".

Satellite digipeat QSO's and APRS short-message contacts are worth three points each, but must be complete verified two-way exchanges. **Remember, only one digipeat contact is allowed for the ISS and one for PCSat.**

The use of terrestrial gateway stations to uplink/downlink is not allowed.

If FO-29 is active, the JA transponder can be used for analog CW and phone activities under the analog transponder rules, and the JD system can be used as a separate transponder under the digital rules.

Sample Satellite Field Day Greetings File:

Greetings from W5BTS Field Day Satellite station near Katy, Texas with 20 participants, operating class 2A, in the AMSAT-Houston group with the Houston Amateur Television Society and the Houston QRP club. All the best and 73!

Note that the message stated the call, name of the group, operating class, where they were located (the grid square would be helpful) and how many operators were in attendance.

3. Operating Class

Stations operating portable and using emergency power (as per ARRL Field Day rules) are in a separate operating class from those at home connected to commercial power. On the report form simply check off Emergency or Commercial for the Power Source and be sure to specify your ARRL operating class (2A, 1C, etc.).

AND FINALLY...

The Satellite Summary Sheet should be used for submission of the AMSAT Field Day competition results to : Bruce Paige, KK5DO, Vice President User Services, P.O. Box 310, Alief, TX 77410-0310.

Make sure to also send your Field Day photographs with your submission! The deadline for submissions is 01 August 2002. You can also send your entry sheet and digital

photos via e-mail to *kk5do@amsat.org*. The first-place emergency power/portable station will receive a plaque 08-09 November 2002 at the AMSAT General Meeting and Space Symposium in Ft. Worth, TX. Certificates will be awarded for second and third place portable/emergency operation in addition to a certificate for the first-place home station running on emergency power. Stations submitting high, award-winning scores will be requested to send in dupe sheets for analog contacts and message listings for digital downloads.

You may have multiple rig difficulties, antenna failures, computer glitches, generator disasters, tropical storms, and there may even be satellite problems, but the goal is to test your ability to operate in an emergency situation. Try different gear. Demonstrate satellite operations to hams that don't even know that the HAMSATS exist. Test your equipment. Avoid making more than ONE contact via the FM-only voice HAMSATS or the ISS, and enjoy the event! ■

Mail your summaries to:

Bruce Paige, KK5DO

Vice President User Services
P.O. Box 310

Alief, TX 77410-0310

See You on Field Day!

AMSAT Satellite Summary Sheet - 2002

Analog Satellite Operation

Satellite/Mode	CW QSO's	Phone QSO's
Multiplier	x 3	x 1
Analog Subtotals		

Digital Satellite Operation

Satellite	Upload/Downloads
Multiplier	x 3
Digital Subtotal	

Score Calculation

Analog CW Subtotal (above)	
Analog Phone Subtotal (above)	
Digital Subtotal (above)	
GRAND TOTAL	

Your Field Day Callsign____________________________

Your Group Name________________________________

ARRL Field Day Classification__________Section__________

Power Source: Emergency____________Commercial__________

Your name and home call____________________________

Home address____________________________________

____

Comments____

____

____

An Ariane 4 rocket (V-151) carried SPOT-5 and the amateur payloads into orbit on 03 May 2002. The two picosats, designed, built and founded by AMSAT-France are both battery powered and should work in space about 40 days. They will remain fastened to the third Ariane 4 stage, with a planned orbit of 800 km.

AMSAT Journal Telemetry

AMSAT-NA Chief visits VK

Jim Linton VK3PC

The President of AMSAT-NA, Robin Haighton VE3FRH, was billed as an international amateur satellite expert for his recent talk in Melbourne. He not only lived up to that description, but showed he is a down to earth and keen active radio amateur.

Robin said the pioneering work of radio amateurs that began at the turn of the last century leading to many communication facilities we now enjoy, is being carried on today by AMSAT with innovation and the development of many ideas within small satellites.

His talk at the Moorabbin and District Radio Club was attended by 90 radio amateurs, included details about a new satellite project. .

AMSAT-NA has just signed a contract with a US firm SpaceQuest for the Low Earth Orbit (LEO) satellite called *Echo*. He said, "This microsatellite with 8-watts downlink and very sensitive receivers will enable users to communicate using analog voice on several VHF uplink and UHF downlink channels simultaneously - but with handheld QRP power!"

Other features of *Echo* will be APRS packet data, and PSK-31 operation (28 MHz up/70cm down), uplink voice or data on 23cm, 2-meters or 10-meters with a 70cm downlink.

"It will be over Australia every 90 minutes with passes ranging from 10 to 20 minutes, depending how directly it passes over Australia at any one time," Robin explained.

In another project, AMSAT-NA is moving ahead with Project Eagle, which will complement AO-40, be put into a similar geosynchronous transfer orbit, and cover the 70cm band, the 2-meter, S and L bands. It is hoped to be launched in 2004.

Also on the drawing board, Germany's AMSAT-DL is in the preliminary stages of planning a mission to the planet Mars in about 2007-8. It would probably use a satellite about the size of AO-40.

AO-40 – Success Out of Post-Launch Failure: Using a Power Point presentation Robin provide a step-by-step look at the Phase 3D AO-40 satellite, the most ambitious amateur satellite project ever.

Its configuration is six-sided, with solar panels on each side, and its weight is 632kg. When the solar cells are deployed they are about 7-metres across.

Robin conceded that in his opinion "AO-40 took too long to build, it's too big in size and complexity, and we have had some failures with it."

Apart from the disappointing loss of its 2-metre transmitter due to internal damage to the satellite, Robin said AO-40 is working extremely well.

Its originally intended orbit would not have favoured the southern hemisphere, but its current orbit, the result of propulsion difficulties, is giving very good reception in Australia.

He explained how it was launched on November 16, 2001, into an almost perfect geosynchronous transfer orbit, and within a few hours telemetry was being received from its 2-meter beacon.

It was necessary to make some orbital changes and stablization, before AO-40 was open for general use by radio amateurs

Robin explained that all was going well until December 2000 when the satellite's 400-newton motor was operated. During one burn attempt nothing happened, due to a suspected sticking valve.

On a later burn of the motor was due to last three minutes, the motor did not shut off for

a further two to three minutes, placing it in a higher apogee orbit.

On December 11, 2000, while remotely working the troublesome fuel valve, a sudden loss of signal from the satellite occurred. Robin recalled how everyone feared that AO-40 has suffered an onboard explosion, or thrown into an orbit away from earth.

"All we could do for about three days was weep," he said, "but fortunately NORAD (North American Aerospace Defence Command) found it to be in one piece, and not a thousand pieces as we had thought."

After a lot of experimentation, ZL2AOX, found he could activate one of the satellite's transmitters. That was on Christmas Day 2000 (UTC) when he put up signals on 70cm and activated the S-band (2.4 GHz) transmitter on the satellite, and downlink telemetry was successfully recovered.

Robin said, "It was the happiest Christmas many radio amateurs around the world had had for many a long year."

The satellite was then painstakingly tested, and progressively brought into service, with the S-2 band transmitter opened for general use on 5 May, 2001.

Found to be working fine were the 70cm and 1.2 GHz receivers, the S-2 (2.4 GHz) transmitter, the magnetorquing system (to control the satellite spin rate), onboard cameras, and high-gain antennas.

One of the cameras has already transmitted pictures of earth from space. In the middle of this year AMSAT plans to take a series of images of earth from the satellite, transmitted digitally via its RUDAK system.

A unique feature on AO-40 is called LEILA, which senses excessively powered SSB uplinks, gives an audible warning, and then notches out the offending signal preventing its access, and "hogging" of the transponder.

Robin encouraged radio amateurs to consider using AO-40 with its orbit providing excellent coverage over many hours.

A 70cm SSB transceiver with a beam for the uplink, and a relatively cheap 2.4GHz downlink receiver and antenna are required. A number of regular operators are using AO-40 while portable, showing it is relatively easy.

Apart from SSB telephony the satellite is also being used for digital contacts, PSK31, and some SSTV.

Giving NASA Useful Data: While AO-40 was being built, NASA approached AMSAT with a Global Positioning System (GPS) package and asked if it would be interested in putting it on board the satellite.

Robin said the NASA project was to try and determine the location of the satellite which is outside the orbit of the GPS ring of satellites.

NASA stipulated that its package needed to be tested early in the orbit life of AO-40, since none of the equipment was radiation hardened, and not expected to last the rigors of space more than three months.

The propulation difficulties experienced meant it was a year before AMSAT could get around to activating the NASA GPS package.

Nevertheless, everything worked 100 percent giving NASA excellent data. The outcome is that using GPS, satellite orbits can be more accurately measured, which will mean that in the future more orbit slots are now possible over the equator for geostationery satellites.

Robin said, "NASA is looking on us very favourably and saying 'hey you guys did a great job for us and now what can we do for you?' ... and discussions are ongoing and look most encouraging."

Both AMSAT-France picosats transmit NBFM voice recorded messages and digital telemetry data. Frequencies listed are 145.840 MHz and 435.270 MHz. Telemetry data will be transmitted at 400 baud BPSK. A complete summary of these satellites is planned for the next issue of *The AMSAT Journal*. (photo courtesy of Jean-Louis Rault, F6AGR)

Assistant to AMSAT-NA President

AMSAT-NA President Robin Haighton, VE3FRH announced that Barry Delong, VA3BJD has agreed to serve as his assistant. Barry will assist Robin in day-to-day AMSAT duties.

Two DX Transponders for VUSAT are Ready

Nagesh Upadhyaya has informed us that the first working models of Mode-B transponders from Italy and Netherlands are ready for delivery for VUSAT.

These are being accepted by AMSAT-India in true spirit of ham radio on a international friendship basis from AMSAT-Italy President Paolo Pitacco, IW3QBN and William Leijenaar, PE1RAH.

William's model transponder is being brought to India by Dom, VU2DOM who met him for an eye-ball meeting in Venlo. The Italian version is being shipped. Both were expected to arrive by the first week of March 2002. A final version of one or both of these may fly on VUSAT subject to testing, qualification and final acceptance by ISRO. Three related photographs are uploaded in the photo section of VUSAT on yahoogroups.com.

Mike Sequin, N1JEZ (left) reports successful K-Band contacts via AO-40. Mike is an area coordinator and exhibits AMSAT technology at many local hamfests.

According to highly reliable sources, AMSAT-India proposal for project VUSAT is at a highly advanced stage of consideration and near-approval with Indian Space Research Organization (ISRO). In all possibility the launch will be scheduled during the year 2003. Possible configuration would include a mode-B (UV) linear transponder by VU-hams, a DX transponder (Dutch/Italian), an fm-message beacon and a Telemetry beacon in independent modes of operation. VUSAT will fly on a 40-kg microsatellite on ISRO's Polar Satellite Launch Vehicle as a co-passenger. It will be India's first microsatellite too. We hope 2003 will be dream-come-true for Indian Hams! AMSAT-India thanks the international community for the excellent support for the project.

Boston AMSAT Net Achieves Three Milestones

Ernie MacLauchlan, K1ELA

The AMSAT Net in the Boston area has been on the amateur 2m band weekly on Thursdays at 8:30 - 9:30 PM. Established on 14 March1996 using the Waltham Repeater 146.640 MHz, the net achieved two milestones on 14 March 2002 with its six anniversary 300th net. Two weeks later, the Boston AMSAT Net achieved another milestone on 28 March 2002 with the 5000th check in. Thanks to all who have checked in over the years and to George Caswell, W1ME for getting me started in the first place!

K-Band Success on AO-40

Mike Seguin, N1JEZ

I'd like to report several successful QSO's using the K-band downlink of AO-40. My initial contact was completed at 1737 UTC on Saturday, 04 April 2002 between Jerry Brown, K5OE and myself, N1JEZ using SSB.

First, I'd sincerely like to thank Jerry for agreeing to the sked, rushing around to get antennas in place and chasing this neurotic operator around the transponder as he attempted to deal with QSB and Doppler effects. Thanks Jerry! Jerry was running L/s. I was running L/k. I used the same setup I had used the previous week to copy the K-band beacon.

Today (Sunday, 21 April 2002), I was again on during the K-band window and worked K5OE and Steve, Gocala, KB8VAO (thanks Steve). I was able to hear signals from Europe, but ran out of time to make a QSO. I hope to try again soon.

I'll upload new pictures and audio of the QSO's to my WWW site at *http://hometown.aol.com/mike73/index.html*

AMSAT Goods Available On-Line

AMSAT-NA's Executive Vice President Keith Baker, KB1SF, recently announced that AMSAT-NA is now accepting orders for AMSAT's various printed, hardware and software items on-line, via a secure credit card link. In addition, a new toll-free number at AMSAT-NA Headquarters in Maryland has been launched to help make telephone ordering of these offerings that much easier.

"These two order simplification efforts have been in the planning stages for a long time," KB1SF said. "With heartfelt thanks to the superb efforts of a number of our super-talented volunteers, our dreams are now a reality." Keith singled out the ongoing, "behind the scenes" work of Paul Williamson, KB5MU, AMSAT-NA's Webmaster, as well as the efforts of Bob Carpenter, W3OTC (along with Martha at the AMSAT office) as particularly noteworthy in bringing these long-needed improvements to AMSAT's member support activities.

As ANS readers know, AMSAT-NA is a non-profit corporation, and as such, offers various informational and promotional items to members and others in exchange for monetary donations. These donations, in turn, help fund the organization's satellite building and launching efforts as well as help cover day-to-day operating expenses.

The new on-line ordering system now makes it easier for members to order these items than ever before. Overseas members will find the new system particularly helpful, as it avoids the need for them waiting until AMSAT's Silver Spring offices open or placing expensive long-distance telephone calls when ordering. Now, such orders can be taken and accepted on-line at any time, day or night, from anywhere in the world.

Members and others interested in using the new on-line service can do so simply by clicking on the AMSAT catalogue link at the bottom of the main AMSAT-NA web page and then following the prompts and appropriate links from there. The final checkout page uses full security encryption and accepts both VISA and MasterCard credit cards.

KB1SF reports that members and others who still wish to place their orders *the old fashioned way* (via telephone or by mail) can continue to do so. Those calling from the continental USA, however, can also now take advantage of a brand new toll free ordering number at AMSAT-NA Headquarters. The number is: 1-888-322-6728.

Second Call For Papers For 2002 AMSAT-NA Annual Symposium

The 2002 AMSAT-NA Annual Symposium is scheduled for 7-11 November 2002 in Fort Worth, Texas. This is the second "Call For Papers" to be presented during the 2002 Symposium.

Papers may be presented by the author during the Symposium, or simply offered for inclusion in the symposium proceedings.

The subject matter should be of general interest to Amateur Radio operators involved in satellite communications. Suggested topics include; operating techniques, antenna design and construction, spacecraft design and construction, current mission status, proposed satellite missions, telemetry acquisition and relay, satellite microwave projects, etc.

A brief abstract of the proposed paper (in outline format) should be submitted as soon as possible. The final date for abstracts is 8 July 2002. Copy-ready papers must be received no later than 26 August 2002.

Electronic submittal is preferred. The format must be either MS Word compatible or in plain text. Please e-mail your electronic submittals to Doug Howard at *douglas.s.howard@lmco.com*.

AMSAT-NA at National Air and Space Museum Space Day. AMSAT technology was exhibited at National Space Day. From left to right are AMSAT Board of DirectorTom Clark, W3IWI; Tom Miller, K4IC; Astronaut/Senator John Glenn; and Bob Burninga, WB4APR. (Photo by Art Feller, W4ART)

AMSAT-UK Colloquium Competition

In conjunction with the first anniversary of two-way communication through AO-40, AMSAT-UK is pleased to announce the 2002 Colloquium Competition. This year the competition is for the *smallest* operational AO-40 groundstation.

The precise definition of *smallest* will be left to the judges who will be appointed by the attendees during the first session at this year's AMSAT-UK Colloquium. It is expected that the definition will take into account the concepts of size, weight, portability, power consumption and other suitable parameters.

There will be two entry categories:

- Category A: Stations set-up and demonstrated at the Colloquium

- Category B: Stations set-up and demonstrated elsewhere, and reported with the fullest detail possible to the Colloquium

Category A judging will take place at a suitable time and place during the Colloquium after the on-site demonstrations have been

completed. Category B judging will be completed after station descriptions have been reviewed. Station description should be sent by e-mail to *G3VZV@amsat.org*

Cash prizes will be awarded to the winner of each section, with the winners to be announced at the Colloquium and on the AMSAT-UK website.

The annual AMSAT-UK Colloquium will be held at the University of Surrey, in Guildford, Surrey, United Kingdom, 26-28 July 2002.

AO-40 Update

The AO-40 command team reports the satellite has now achieved an improved solar angle, with enough available power to activate the RUDAK, GPS, and CEDEX systems.

In its short lifetime, AO-40's GPS and CEDEX experiments have yielded exciting preliminary data, and the command team, along with the experimenters (including the folks at NASA) are anxious to receive new data.

RUDAK command stations have uploaded the necessary software, and after successful testing, several stations around the world are now downloading RUDAK data.

The GPS apogee receiver seems to be working fine. Three files were downloaded and sent to NASA. A quick look indicated they contained reasonable looking data. Further data analysis will be done soon by the GPS group at Goddard. The plan is to continue to download and forward that data as it is collected.

Data collected last fall indicated unexpectedly strong signals from several orbiting GPS satellites.

The CEDEX experiment was turned on and it was verified it was talking to RUDAK. However, only time stamps were being received. AO-40 command stations will continue to work with the system. The CEDEX data from last fall clearly showed the satellite traveling through the Van Allen belts. It also showed some interesting features just outside the known belts. The measurements of the amount of radiation exposure to the electronics in AO-40 are extremely helpful for future design efforts.

Now that RUDAK is functional, there may be occasional periods, (particularly when it is visible over Australia), that RUDAK is activated briefly outside of the nominal window - to check on the directory status, etc. Please bear with these interruptions. If they occur, they should be of short length. In addition, AO-40 has been experiencing very intense RADAR interference, that makes commanding difficult on U-band and extremely difficult on L-band. This has happened once before (September-October 2001). At that time, it only lasted about a week. If commanding is not possible because of interference on U/L bands, it may be necessary to switch on the V-band receiver. This will turn off the U-band receiver and uplink during this time. Again, please bear with the command team if this becomes necessary, it should be of short duration.

In summary, the command team is pleased the GPS receiver (at least the apogee unit) is functioning normally after this long period in a high radiation orbit. The hope is to get CEDEX fully operational and gather some data from it. Work with the other hardware and experiments will be undertaken as time allows.

Stacey Mills, W4SM, has updated his P3T/AO-40 telemetry program by modifying the output telemetry to include a UDP format, suitable for transmission to the Goddard telemetry server. The UDP option is in the TCP/IP window. The Help file also contains information regarding setting up this feature.

You can get the updated version of P3T at the W4SM web site.

TAPR Call for Papers

Technical papers are solicited for presentation at the 21st Annual ARRL and TAPR Digital Communications Conference to be held 13-15 September 2002 in Denver, Colorado. Annual conference proceedings are published by the ARRL. Presentation at the conference is not required for publication. Submission of papers is due by 5 August 2002.

The ARRL and TAPR Digital Communications Conference is an international forum for radio amateurs to meet, publish their work, and present new ideas and techniques. Presenters and attendees will have the opportunity to exchange ideas and learn about recent hardware and software advances, theories, experimental results, and practical applications.

Topics will include software-defined radio, digital voice satellite communications, global position systems, APRS, digital signal processing, HF digital modes, internet interoperability with amateur radio networks, spread spectrum systems, and much more.

Conference registration details and updates, along with more information are available at *http://www.tapr.org/dcc*

RS-21 Deorbits

Alex Papkov at Kaluga Ground Control in Russia reported to ANS that RS-21 has re-entered the atmosphere. Papkov provided the following announcement:

Trajectory calculation of lowering of the microsatellite, using the last navigation data, gives its atmospheric re-entry on orbit 711, somewhere above the Pacific Ocean. Thus, the microsatellite Kolibri-2000/RS-21 has successfully completed the operation and has stopped any physical existence.

We consider all aspects of this mission to have been a success. Collaboration between Australian high school students, Russian Space scientists and Russian high school students has been a highlight. The satellite's formal name was the Russian-Australian Scientific and Educational Microsatellite.

Radio Sport RS-21, was remotely launched on 20 March 2002 from a Russian Progress M-1-7 launcher. During its lifetime, RS-21 sent telemetry data and digitally recorded voice messages in a circular orbit just over 200 miles above the Earth.

SaudiSat 1A

AMSAT-NA News Service (ANS) has received word via AMSAT-NA President Robin Haighton, VE3FRH, that SaudiSat 1A is now open for amateur radio communications. In a letter to VE3FRH, Turki Al-Saud, the director of the Space Research Institute in Riyadh, Saudi Arabia (the sponsoring agency) communicated the following:

Please announce the availability of SaudiSat 1A (SO-41) to AMSAT members and to follow Amateur Radio operators in your region. Saudi OSCAR-41 has been configured for operation in the amateur service. The spacecraft will automatically enable its UHF transmitter over Saudi Arabia and the United States for approximately 20 minutes each pass.

The spacecraft is operating in Mode J, centered on a VHF uplink and UHF downlink of 145.850/436.775 MHz, currently configured as an analog FM voice repeater. The spacecraft will operate in this mode intermittently, as power and spacecraft experiments permit.

SO-41's downlink RF power is 1 watt over both regions with left-hand circular polarization. The uplink antenna (located on top of the spacecraft) is linear in polarization.

Best regards,

Turki Al-Saud
Space Research Institute
Riyadh, Saudi Arabia

SO-41 was launched September 26, 2000, aboard a converted Soviet ballistic missile from the Baikonur Cosmodrome.

Immediately following the announcement, signal reports were being noted on the AMSAT-BB mailing list. Don, KD4APP, reported signals were running S1-S2. Drew, KO4MA, reports working WA3WDR and N4TPY. Joe, KA0YOS reported "SO-41 sounded good in South Dakota."

SaudiSat 1B is not available at this time as experiments and software development continues with 1B.

2002 Dayton Hamvention

The 2002 Dayton Hamvention is now history. Despite cold temperatures over the entire weekend of 17-20 May 2002 and rain on Friday, Dayton Hamvention was very successful for AMSAT. A full report detailing AMSAT's activities will be in the next of *The AMSAT Journal*. In the meantime, here are some snapshots of AMSAT activities at this year's Dayton Hamvention.

ARISS Participates at the Sally Ride Festival, George Mason University. On 11 May 2002, ARISS Coordinator Will Marchant, KC6ROL gave a talk on satellite communications at the Sally Ride Fesitval. As a part of the talk, the group listened to a pass of the International Space Station and how they could get involved through ham radio.

Rick Hambly, W2GPS highlights OSCAR-Echo, AMSAT's newest satellite project, at the AMSAT booth. In front of Rick is the engineering mockup of OSCAR-Echo, which was on display at the booth. On the left is the Microsat mechanical test model used for vibration testing of the design that eventually became AO-16, DO-17, WO-18, and LU-19. Rick is a member of the OSCAR-Echo project team.

Mike Seguin, N1JEZ of Burlington, VT successfully received AO-40's beacon on K-band using his station in the parking lot of Hamvention. This was no small feat, as he painstakingly searched for AO-40 in the sky, overcoming Doppler shift and using a narrow beam width antenna without the benefit of knowing exactly where his antenna was pointing in azimuth

Howard Long, G6LVB of London, England (in sunglasses) gave an AO-40 demonstration following the AMSAT Forum on Saturday. About 70 people watched Howard use a portable AO-40 station to work the satellite.

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PUBLICATIONS

Working the Easy Sats - An informal introduction to the amateur satellite program plus hints on using the more easily accessed satellites. $6.00 US; $7.00 Canada; $10 elsewhere.

P3G to P3D The Provisional Preliminary Pre-flight Guide to Phase 3D - $10 US; $12 Canada and Mexico; $15 elsewhere.

.**The Satellite Handbook** by K2UBC and published by ARRL is perhaps the finest book of its kind ever written for the Amateur. With 376 pages, this 1998 edition contains everything you need to know about amateur satellites: operating, antennas, software, profiles of active satellites and more. $25 US; $32 Canada and Mexico; $40 elsewhere.

The AMSAT-NA Digital Satellite Guide - Newly revised, AMSAT's complete step-by-step instruction guide to operating through the PACSATs. Covers all facets of digital satellite operation, modes and frequencies, and provides information on digital satellite station equipment. Also includes two chapters on WISP. $15 US; $18 Canada and Mexico; $23 elsewhere.

The Analog Satellites Operating Guide - Newly revised guide to aid amateur operators in working the RS satellites, UO-14, AO-27, FO-29, AO-10, AO-40 and ISS. It takes you step-by-step through the process of equipping the station, finding the satellites, using the transponder and finally making a QSO. Explanations and examples of how to decode the telemetry sent from the satellites is also included. $7.00 in US; $9.00 in Canada and Mexico; $14 elsewhere.

Mode S: The Book - Revised April 2001, 134 pages. The complete guide to setting up and operating a Mode S Satellite ground station. $15 in US; $18 Canada, Mexico; $23 elsewhere.

Proceedings of the AMSAT-NA 19th Space Symposium and AMSAT Annual Meeting (2001) $15 US; $20 Canada,Mexico; $25 elsewhere.

2002 Amateur Satellite Frequency Chart - $6.00 in US; $7.00 Canada and Mexico; $8.00 elsewhere

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